STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
OFFICE OF TRANSPORTATION LABORATORY

SEDIMENT BASINS WITH SLOTTED RISER OUTLETS: AN EVALUATION

E47

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16. ABSTRACT

An evaluation of sediment basins formed by installing slotted risers on existing highway culvert inlets along State Route 299 in Trinity County, near Redding, California is documented.

Grain sizes of the sediment retained in the basins and of sediment that passed through the slotted risers during storms were measured. The sediment is decomposed granite. The volume of retained sediment was measured four times from the time the basins were built in 1978 to 1983.

Hydraulic operating characteristics were observed during two storms in January, 1983.

The slotted risers promoted rapid drainage and minimized ponding in the basins. However, since the storage capacity of some of the basins was too small, they filled up rapidly with sediment and their trapping efficiencies decreased. These basins will require more frequent cleanouts.

This is a follow-up study to a previous Caltrans project entitled "Sediment Accumulation at Highway Culverts Modified with a Slotted Pipe Riser on Inlet", report No. CA/TL-80/25, June 1980.

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CONVERSION FACTORS

English to Metric System (SI) of Measurement

Quantity	English unit	Multiply by	To get metric equivalent
Length	inches (in)or(")	25.40 .02540	millimetres (mmm) metres (m)
	feet (ft)or(')	.3048	metres (m)
	miles (mi)	1.609	kilometres (km)
Area	square inches (in^2)	6.432×10^{-4}	square metres (m^2)
	square feet (ft^2) acres	.09290 .4047	square metres (m^2) hectares (ha)
Volume	gallons (gal)	3.785	litres (l)
	cubic feet (ft^3)	.02832	cubic metres (m^3)
	cubic yards (yd^3)	.7646	cubic metres (m^3)
Volume/Time (Flow)	cubic feet per second (ft^3/s)	28.317	litres per second (l/s)
	gallons per minute (gal/min)	.06309	litres per second (l/s)
Mass	pounds (lb)	.4536	kilograms (kg)
Velocity	miles per hour (mph) feet per second (fps)	.4470 .3048	metres per second (m/s) metres per second (m/s)
Acceleration	feet per second squared (ft/s^2)	.3048	metres per second squared (m/s^2)
	acceleration due to force of gravity (G)	9.807	metres per second squared (m/s^2)
Weight Density	pounds per cubic (lb/ft^3)	16.02	kilograms per cubic metre (kg/m^3)
Force	pounds (lbs) kips (1000 lbs)	4.448 4448	newtons (N) newtons (N)
Thermal Energy	British thermal unit (BTU)	1055	joules (J)
Mechanical Energy	foot-pounds (ft-lb) foot-kips (ft-k)	1.356 1356	joules (J) joules (J)
Bending Moment or Torque	inch-pounds (ft-lbs) foot-pounds (ft-lbs)	.1130 1.356	newton-metres (Nm) newton-metres (Nm)
Pressure	pounds per square inch (psi)	6895	pascals (Pa)
	pounds per square foot (psf)	47.88	pascals (Pa)
Stress Intensity	kips per square inch square root inch (ksi $\sqrt{in}$)	1.0988	mega pascals $\sqrt{metre}$ (MPa $\sqrt{m}$)
	pounds per square inch square root inch (psi $\sqrt{in}$)	1.0988	kilo pascals $\sqrt{metre}$ (KPa $\sqrt{m}$)
Plane Angle	degrees (°)	0.0175	radians (rad)
Temperature	degrees fahrenheit (F)	$\frac{tF - 32}{1.8} = tC$	degrees celsius (°C)

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Special recognition is due the maintenance personnel of the Buckhorn Maintenanace Station under the supervision of Bill Powell for keeping portions of Route 299 open during severe storms.

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1. INTRODUCTION

This report documents the investigation of a mitigation measure for reducing the amount of sandy sediment in Little Grass Valley Creek, a tributary of the Trinity River.

A cooperative agreement was executed in 1978 among Caltrans District 02, the California Department of Water Resources, and the California Department of Fish and Game. Sediment basins, also known as debris basins, were constructed in spring, 1978 as part of the Trinity River Fishery rehabilitation program.

Sediment basins were formed by installing slotted risers on the inlets of existing highway culverts. The culverts were 24 and 36 inch diameter corrugated steel pipes. The surrounding areas were regraded to drain to the risers. The basins are located along State Route 299 in Trinity County, approximately 50 miles northwest of Redding, California. See Figure 1.

The Transportation Laboratory (TransLab) originally measured the volumes and grain sizes of sediment in seven of the basins from 1978 to 1980 [1]. The results of the study are incorporated in this report.

The purpose of this study was to reevaluate the basins four years after construction. Field observations were made during the 1982-83 winter. The volumes and grain sizes of the sediment retained in the basins were measured as was done from 1978 through 1980. Additionally, the hydraulic operating characteristics of the basins and the grain sizes of sediment that passed through the slotted risers during storms were studied.

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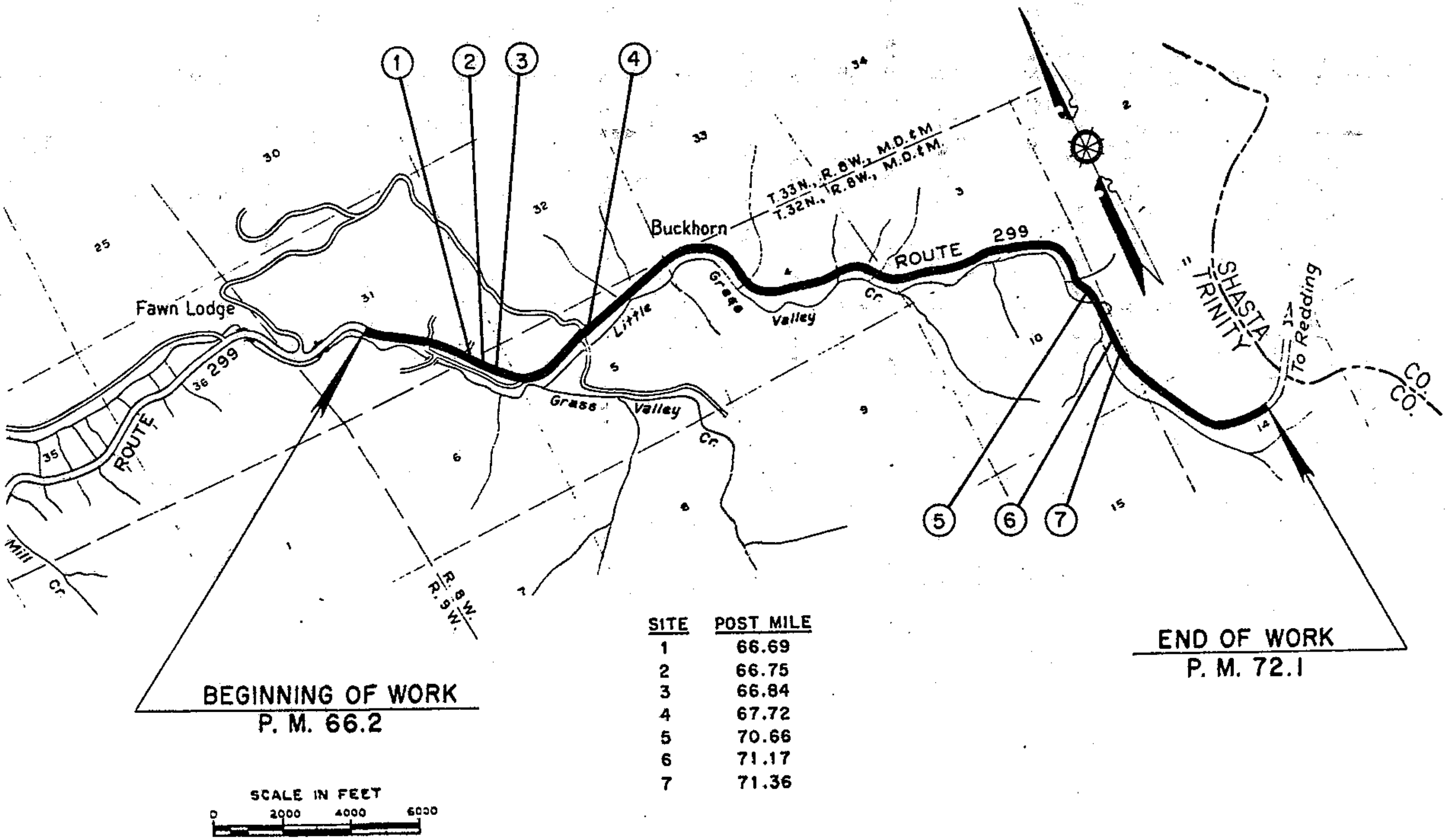

SITE	POST MILE
1	66.69
2	66.75
3	66.84
4	67.72
5	70.66
6	71.17
7	71.36

LOCATION MAP

FIGURE 1

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Data were collected manually. Interbasin comparisons were qualitative due to differences in rainfall, basin geometry, drainage area, and sizes and configurations of the slots in the risers.

This report presents the volumes and grain sizes of sediment retained in the basins, the hydraulic operating characteristics of the basins, and the grain sizes of sediment that passed through the slotted risers during storms. The Appendix contains a photographic log of the basins from 1979 through 1983. In addition, current literature and plans used by Caltrans for designing sediment basins are in the Appendix.

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2. CONCLUSIONS

The sediment basins, formed by installing slotted risers on inlets of existing highway culverts, were effective for trapping much of the sediment entering them.

Particles of sediment smaller than the slots interlocked to form a bridged network, which performed like a filter. Water seeped through voids in the filter and passed through the slots.

The bridged network of sediment was dislodged, however, when runoff flowed directly to the riser. Consequently, sediment as large as the smallest dimension of the slot passed through the culvert.

Slotted risers allowed rapid drainage of the basins. The sediment retained in the basins was very porous and drained easily.

The sediment was decomposed granite of the Shasta Bally Batholith. Sediment retained in the basins was mostly well graded, gravelly sand. Gravel larger than 3/4-inch was not found in the basins.

Sources of sediment were roadway cut slopes and logged areas north of Route 299.

As sediment deposited near the slotted risers, a fan developed. The low spot of the basin migrated away from the riser, providing a longer path to the riser and consequently, more time for particles to settle.

The erosion observed along Route 299 during and after the torrential rains of the January 26, 1983 storm was severe.

The basins at post miles 67.72, 70.66, 71.17, and 71.36 are too small. Since their capacity to contributing drainage area ratios

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are small, these basins rapidly fill with sediment and trapping efficiency decreases. Consequently, the basins will require more frequent cleanouts.

The slots in the riser at post mile 67.72 are too large (9 inches by 3 inches). The majority of sediment and runoff passed through.

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3. RECOMMENDATIONS

General Recommendations

The installation of slotted risers on inlets of existing highway culverts to form sediment basins (or debris basins), is recommended for highway cross culverts, where the attenuation of downstream sedimentation is necessary. However, before this technique is used, geotechnical and hydraulic reviews of each site should be performed. Arbitrary construction of debris basins must be avoided, because retention of runoff for long periods of time can saturate roadway embankments and cause failures [2].

Current literature and plans used in Caltrans for designing sediment basins are listed below and are included in the Appendix.

- Caltrans Highway Design Manual "Entrance Risers" [3].
- California Culvert Practice "Debris Riser"-"Debris Basin" [4].
- Hydraulic Engineering Circular No.9 "Debris Control Structures" [5].
- Caltrans Standard Plans "Drainage Inlet Riser Connections"[6].

Basins formed by installing a riser on the culvert entrance should be properly sized to handle the runoff from their corresponding drainage areas. As a general guideline, the ratio of the basin capacity to drainage area of bare ground should not be less than 40 cubic yards per acre.

Unless they are oversized, basins should not be located where there is no access for maintenance to remove sediment.

Undersized basins require frequent maintenance, and if plugged, may cause roadway flooding or embankment failure.

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The size, shape, and configuration of the slots should be chosen to allow rapid drainage of the basin during severe runoff events.

For new installations, field inspections should be made by a hydraulic engineer during storms to assure that sediment is being retained. If too much sediment is passing through the basin, then some of the slots should be plugged.

A maintenance program of sediment removal and disposal is recommended. The optimum cleanout schedule will depend on the basin geometry. Generally, when the sediment level reaches one half the depth of the slotted riser, the basin should be cleaned out. It is recommended that the riser be marked at the halfway point at the time of installation to signal the time for cleanout.

It is also recommended that sides of the basins and the inflow paths be vegetated to prevent local erosion and to reduce scour.

The inflow paths of concentrated runoff entering a sediment basin should be routed away from the riser. This will reduce scour around the riser. Baffles can be used to divert inflow paths, to dissipate energy, and to provide a circuitous route to the slotted riser. The reduced energy and longer path will enhance sedimentation.

Further study of the size, shape, and configuration of slots is necessary for soils other than decomposed granite.

Specific Recommendations

For basins that will retain sediment similar to the decomposed granite of the Shasta Bally Batholith, the slot sizes and configuration should be 1/2 inch horizontal by 6 inches vertical, spaced 3 inches vertically and from 10 to 15 inches horizontally.

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The area of opening in the pipe wall should be approximately five percent per lineal foot of pipe.

The basins at post miles 70.66, 71.17, and 71.36 should be cleaned out to approximately the original ground limits at the time of their construction.

A field review with maintenance personnel is recommended so that the risers can be marked at the half full points to signal that a cleanout is needed.

Disposal sites should be designated for the sediment removed from the basins. These sites should be environmentally safe and in the vicinity of the basins to minimize hauling and other disposal costs.

A baffle should be placed in the basin at post mile 66.69 to dissipate inflow from the upland drainage area. The baffle would prevent inflow from going directly to the riser.

The flume downdrains at post miles 70.66 and 71.36 should be extended or repositioned to prevent inflow from going directly to the riser.

The size and configuration of the slots in the risers at post miles 67.72, 70.66, 71.17, and 71.36 should be similar to those at post miles 66.69, 66.75, or 66.84.

The capacity of the basin at post mile 67.72 can be increased by increasing the height of the riser.

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4. IMPLEMENTATION

Copies of this report will be sent to Caltrans Districts and Headquarters Offices and to the Federal Highway Administration. This report will also be sent to other agencies upon request. TransLab will be available to assist District personnel who are designing sediment basins.

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5. ROUTE 299 SEDIMENT BASINS: RESULTS

5.1 DESCRIPTION of BASINS

Sediment basins were built along Route 299 by installing slotted corrugated steel pipe (CSP) risers on the inlets of existing culverts. The basins were designed to prevent sandy sediment (decomposed granite) from drainage areas north of the highway from being discharged into Little Grass Valley Creek. Slots were cut in the risers to help drain the basins.

The basin design features and slotted riser characterisitics are shown in Table 1. Since the basins are shaped irregularly, only the overall dimensions are shown. Figure A-1 in the Appendix shows some typical contract drawings of a CSP riser extension, grading details, debris rack, and drop inlet.

One guideline used to approximate the size of a sediment basin is to allow from 40 to 60 cubic yards of capacity for each acre of bare ground in the drainage area [7 and 8]. The Route 299 basins were not designed according to this guideline. Instead, risers were placed on existing culverts and the basins were formed by grading the surrounding areas to drain to the risers.

The basin <u>CAPACITY</u> to drainage <u>AREA</u> <u>RATIOS</u> (CAR's) were calculated for the seven basins studied along Route 299. These ratios are shown in Table 1. Because the soil in the study area is decomposed granite, which is very erosive, the entire drainage area was assumed to be bare. The CAR's for the basins at post miles 67.72, 70.66, 71.17, and 71.36 are less than 15 cubic yards per acre, while those at post miles 66.69, 66.75, and 66.84 are greater than 50

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TABLE 1

BASIN DESIGN FEATURES AND SLOTTED RISER CHARACTERISTICS

Site	Post Mile	Overall Dimensions (feet) Length	Width	Depth(A)	Capacity (yd^3)(E)	Drainage Area (acres)	CAR(C) (yd^3/acre)	Diameter of Riser (feet)	Orientation and shape of slots	Size of slots (inches)	Vertical Spacing (inches)	Horizontal Spacing (inches)
1	66.69	50	60	6.2	450	8.4	54	2		1/2 x 6	3	9.4
2	66.75	30	30	10.3	570	3.5	163	2		1/2 x 6	3	9.4
3	66.84	40	40	10.1	1015	12.7	80	2		1/2 x 6	3	9.4
4(B)	67.72	100	15	4.5	275	23.0	12	3		9 x 3	6	27.0
5	70.66	65	12	1.4	20	7.5	10	2		1-1/2 x 5 & variable	random	random
6	71.17	55	13	2.1	35	7.9	5	3		1-1/4	(D)	(D)
7	71.36	20	35	2.1	65	9.1	7	3		1/2 x 6	3	14.1

NOTES:
(A) = Bottom of basin to lip of slotted riser at riser
(B) = Basin not monitored during 1983 storms
(C) = Basin Capacity to drainage Area Ratio
(D) = 16 holes arranged randomly within 3 feet of riser lip
(E) = Calculated using cross section data, not by multiplying overall dimensions

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cubic yards per acre. Based on these calculations, the basins with small CAR's might be undersized and would probably be less efficient in trapping sediment. The measurements of retained sediment show that the basins with CAR's less than 40 cubic yards per acre were undersized. See section 5.4.1 for the discussion and results of retained sediment measurements.

5.2 PRECIPITATION DATA

The average annual rainfall along Route 299 in Trinity County varies from approximately 55 inches at post mile 66 (elevation 2000) to 75 inches at post mile 72 (elevation 3000) [9]. Rainfall was below normal from 1978-80 [1]. The 1980-81 water year was approximately 90 per cent of normal [10], while both the 1981-82 and the 1982-83 water years were approximately 150 per cent of normal [11 and 12].

The basins were monitored during storms on January 17,18 and again on January 26,27 1983. A post-mounted rain gage was used to record total rainfall. Periodic readings permitted the computation of average intensities during monitoring. Both storms lasted longer than 8 hours with continuous rainfall. A summary of the rainfall data is shown in Table 2.

The ground was saturated because it rained nearly every day during the latter half of January 1983, in Northern California [13]. The recurrence interval of the January 17,18 storm was 2 years, while that of the January 26,27 storm was at least 100 years. The 100 year storm caused fatalities and widespread damage throughout California and other states [14]. There were several mud slides,

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TABLE 2

RAINFALL SUMMARY

Dates	Rain Gage Location (post mile)	Total Rainfall (inches)	Average Intensity During Observations (inches per hour)
January 17 and 18, 1983	71.36 66.84	1.40 0.64	0.14 0.03
January 26 and 27, 1983	71.36 70.66 66.84	8.77 8.00 3.14	0.74 0.63 0.26

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road slope failures, and road closures along Route 299 in Trinity and Shasta Counties.

5.3 HYDRAULIC OPERATION

The hydraulic operation of the basins was monitored during the two storms in January, 1983. Monitoring consisted of studying the sources of sediment, drainage entering the basins, turbulence, scour, ponded depth, areal limits of ponding, outlet flow rates, and the operation of the slots in the risers. Photographs were taken of each basin during these storms. Figures 2 through 7 show the layout of each basin and the drainage features for the January 26,27 storm. The Appendix contains a photographic log of the basins from 1979 to 1983.

The basin at post mile 67.72 was not studied. As reported in [1], water did not pond in this basin because the slots in the riser were too large (9 inches by 3 inches). Outlet flow rates and samples of passed sediment could not be collected during the January 1983 storms, because the outlet was submerged by Little Grass Valley Creek. The retention of sediment in this basin is dependent on chance plugging of the slots by debris.

Instantaneous flow rates were measured using a 5 gallon bucket and stopwatch at the culvert outlets, except at post mile 70.66. Since the outlet at 70.66 was submerged, a flow rate measurement was obtained at the slotted riser.

The basin outlet flow rates are shown in Table 3. The flow rates on January 18 are typical of an annual event, those on January 24 are

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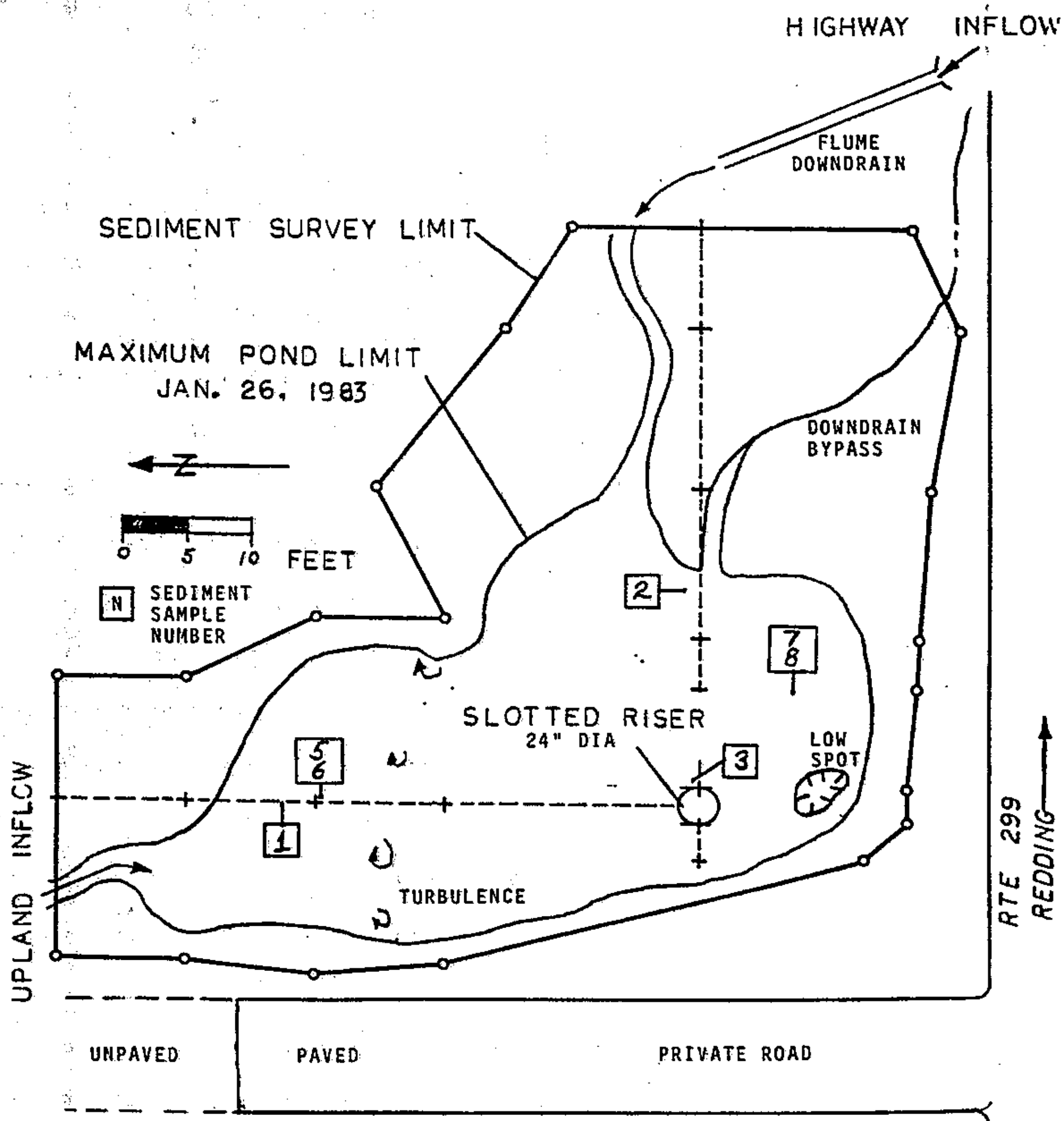

BASIN AT - **P. M. 66.69**

FIGURE 2

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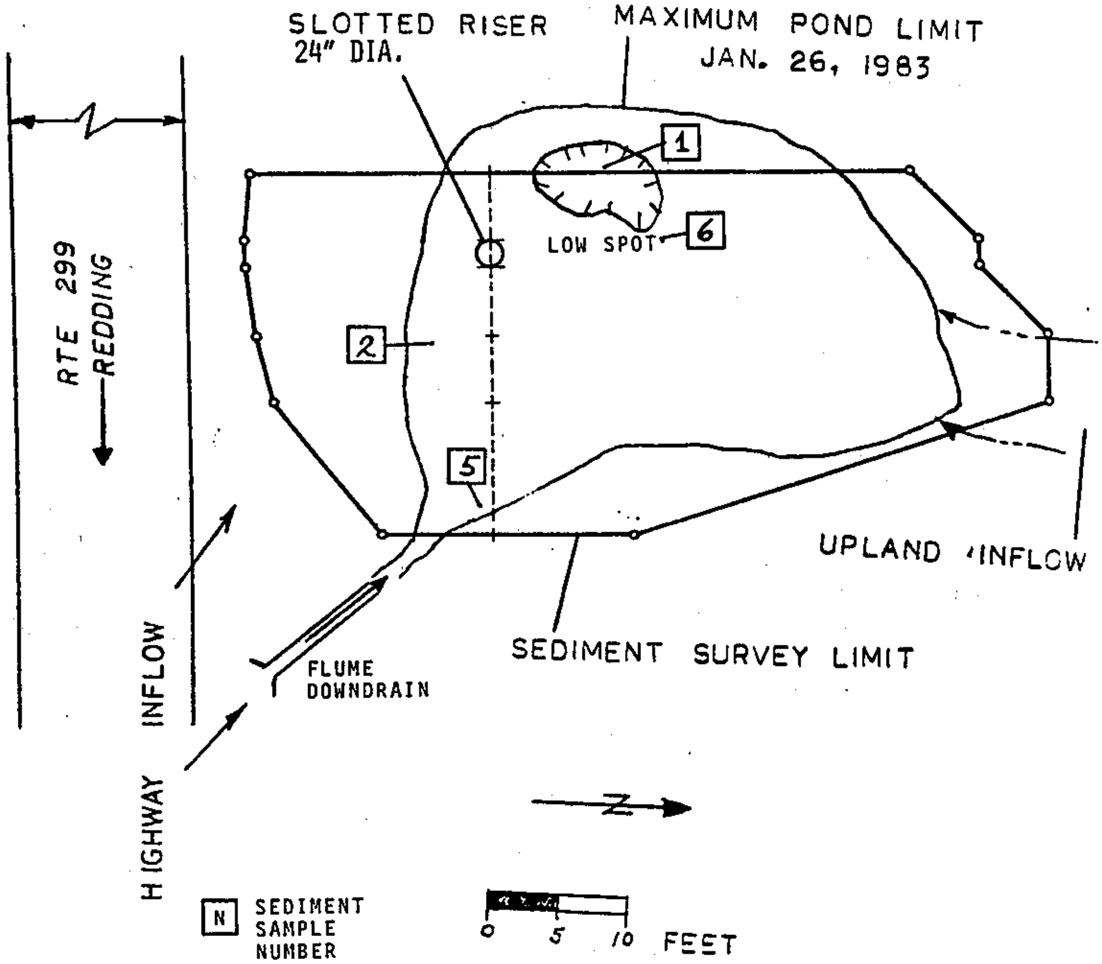

BASIN AT **P. M. 66.75**

FIGURE 3

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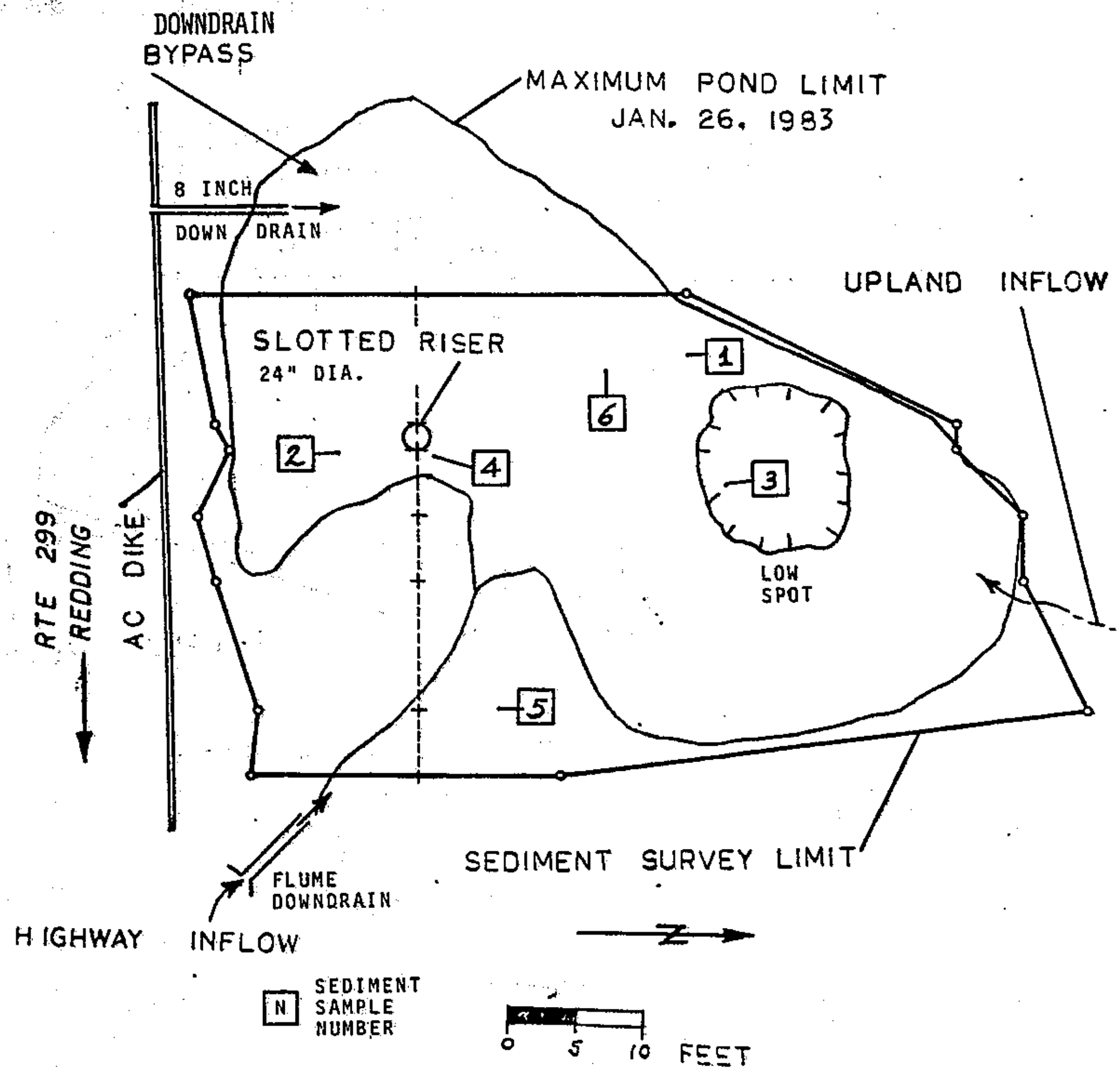

BASIN AT- P. M. 66.84

FIGURE 4

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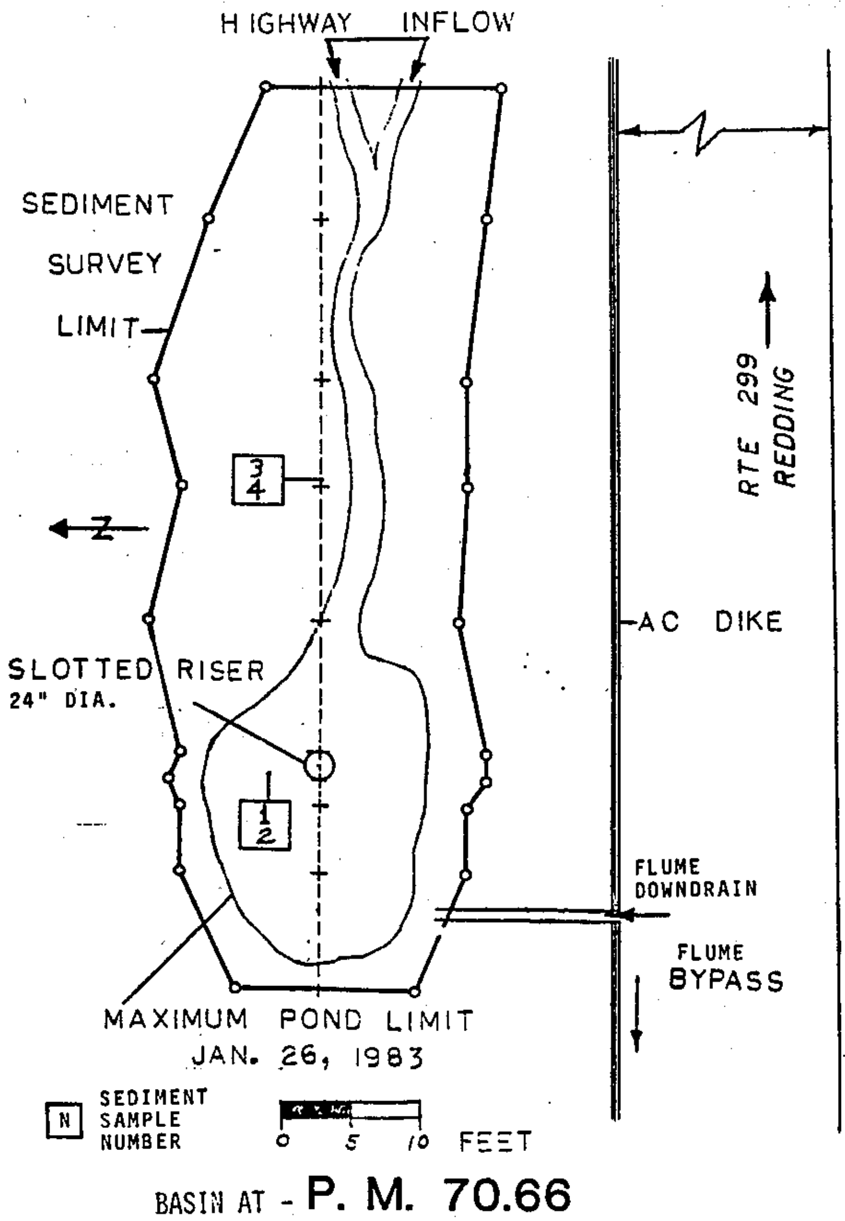

FIGURE 5

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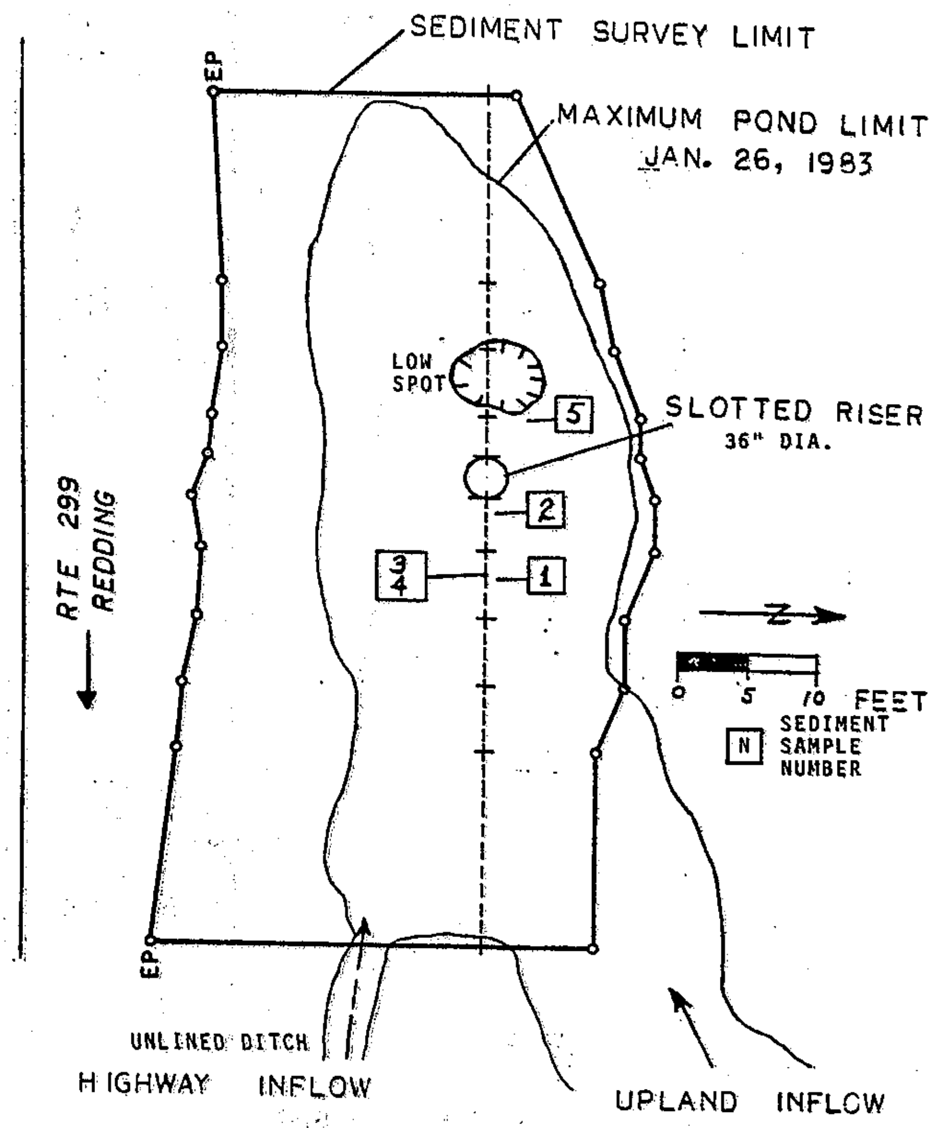

BASIN AT - **P. M. 71.17**

FIGURE 6

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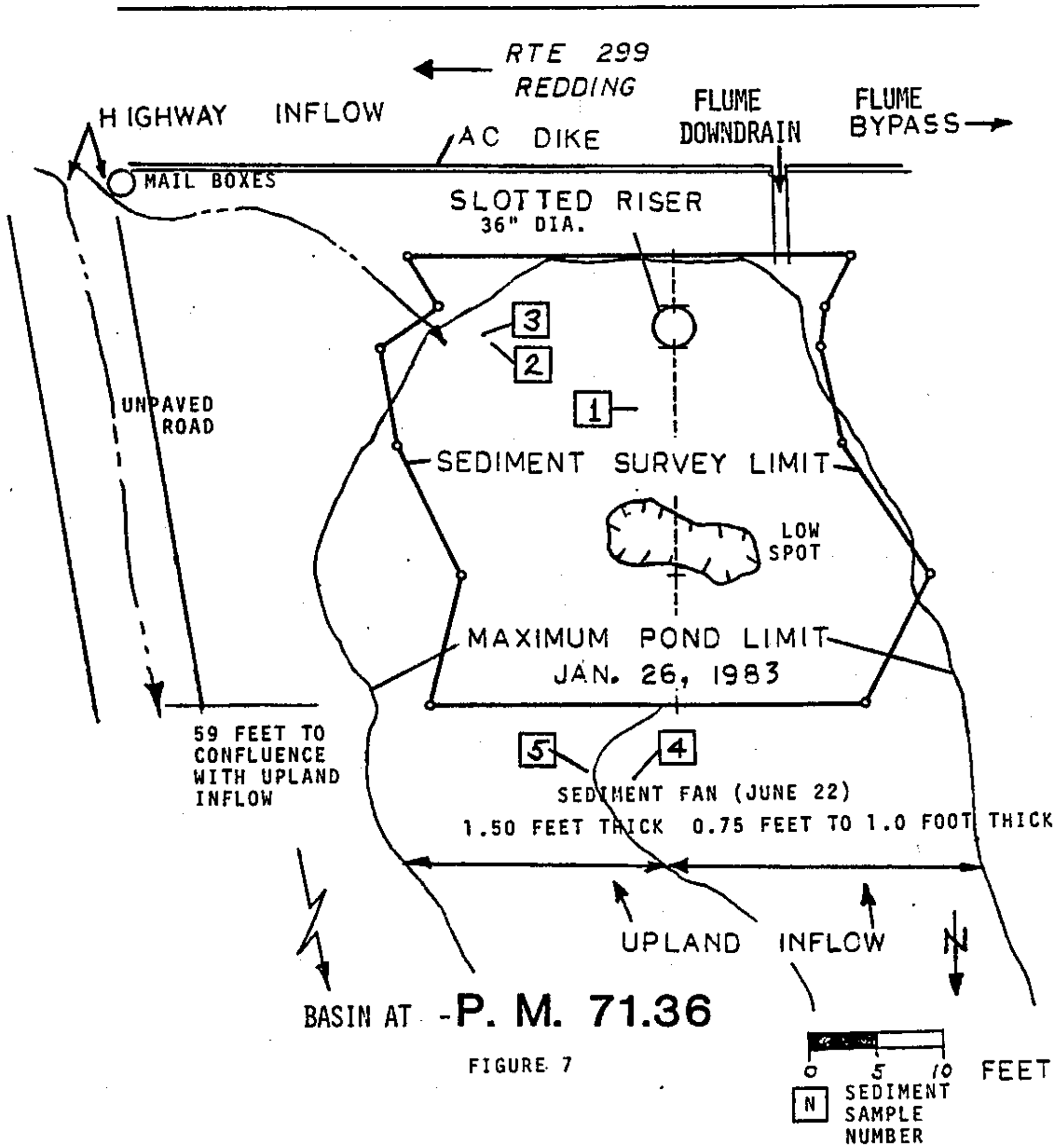

FIGURE 7

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typical of seepage conditions, and those on January 26 are typical of a 100 year (or worse) event.

The ponded depths at the risers in basins at post miles 66.69, 66.75, and 66.84 never exceeded 1.0 foot. The size, number, and configuration of the slots allowed rapid drainage.

The basins at post miles 70.66, 71.17, and 71.36 were already full of sediment. Consequently, there was no ponding. Sediment-laden runoff went directly to the slotted risers and passed through the culverts. These risers operated as circluar weirs with heads of approximately 0.1 foot to 0.3 foot. Submerged orifice flow was not observed.

Figures A-26 and A-29 in the Appendix show water flowing through the slots of the risers at post miles 71.17 and 71.36. During the receding segments of the storms when the basins were still saturated, there was little to no ponded water. Water seeped through the retained sediment and passed through the slots. Water samples were collected for total residue testing during the seepage conditions. See Section 5.4.2, "Passed Sediment".

Turbulence was seen in basins 66.69, 66.75, and 66.84 at the inflow/pond interfaces. See Figure 2.

5.4 SEDIMENTATION CHARACTERISTICS

In addition to observing the hydraulic operation of the basins, volumes and sizes of sediment retained in the basins were determined during dry periods. Samples of sediment which passed through the basins were collected during storms for grain size analysis.

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TABLE 3

BASIN OUTLET FLOW RATES

Post Mile	Instantaneous Flow Rate (ft^3/S)		
	Jan. 18, 1983	Jan. 24, 1983	Jan. 26, 1983
66.69	trace	0.001	0.22
66.75	0.02	0.003	0.10
66.84	zero	0.008	0.07
70.66	no data	0.002	0.18
71.17	0.07	0.002	1.34
71.36	0.14	0.05	1.34

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5.4.1 Retained Sediment

The volume of sediment retained in the basins was measured four times after the slotted risers were installed in 1978. Cross sectioning was performed with a self-leveling level and Lenker rod. Reference stakes were established at the ends of each station. The same cross sections were surveyed each time, using the same elevations and offsets for the end points only, so that the MULTIPLE ROADWAY option of the HIDES computer program could be used [15]. Normally the stakes were set at elevations just above the lip of the slotted riser, since it was expected that the basins would fill with sediment. In Figures 2 through 7 the line labelled 'SEDIMENT SURVEY LIMIT' was drawn through the end reference stakes.

The cross section notes were submitted to the Caltrans Office of Computer Systems and processed by the HIDES earthwork computer program using the MULTIPLE ROADWAY option. The average end area method is used in HIDES to calculate fill (retained sediment) or cut (scour) volumes. The initial set of cross section notes was treated as TERRAIN. The second set of cross section notes was treated as the TEMPLATE. In subsequent surveys, the TEMPLATE became the TERRAIN, while the most recent set of cross section notes became the TEMPLATE.

Table 4 shows the volumes of retained sediment for each of the four measurement periods from 1978 through 1983. The total volumes of sediment accumulated during five years ranged from 9.9 cubic yards at post mile 66.75 to 74.1 cubic yards at post mile 66.69. The sum of the sediment volumes retained by all seven basins was 265 cubic yards.

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TABLE 4

VOLUMES OF RETAINED SEDIMENT AND BASIN CAPACITIES

		Sediment Retained During Period (yd^3)					Capacities (yd^3)	
Site	Post Mile	1978-79	1979-80	1980-82	1982-83	Total 1978-83	Initial	After July 1983
1	66.69	3.2	-1.9	4.4	68.4	74.1	450	375
2	66.75	0.1	0.7	2.4	6.7	9.9	570	560
3	66.84	3.6	7.5	6.0	6.1	23.2	1015	991
4	67.72	0.5	-2.2	9.3	33.8	41.4	275	233
5	70.66	7.5	2.4	8.9	1.1	19.9	19.9	0
6	71.17	5.6	-2.5	0.4	31.2	34.7	34.7	0
7	71.36	6.5	10.1	5.5	39.9	62.0	62.0	0

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The predominant sources of sediment were the highway cut slopes near post miles 66.75, 70.66, 71.17, and 71.36 for the first four years. At post miles 66.69, 66.84, and 67.72 the predominant sources of sediment were the upland reaches of the drainage areas. The sources were determined by observations during storms and by walking the upland reaches of the drainage areas after storms.

During the 1982-83 winter the basins at post miles 71.17 and 71.36 received the majority of sediment from the upland reaches of the drainage areas.

Table 4 also shows the initial capacities of the basins and the capacities remaining after July, 1983.

The basins at post miles 70.66, 71.17, and 71.36 are full of sediment. See Figures A-24, A-28, and A-33 in the Appendix. These basins need to be cleaned out to approximately the original limits of excavation. After the basins are cleaned out, the risers should be marked at a point halfway from the ground to the riser lip to signal the next cleanout.

The basins at post miles 66.69, 66.75, 66.84, and 67.72 will not need to be cleaned out yet. However, the basins at post miles 66.69 and 67.72 are losing sediment periodically. The riser at post mile 67.72 should be replaced with one that has smaller slots, like those at post mile 71.36. See Table 1. At post mile 66.69 a baffle is needed to dissipate inflow from the upland reach of the drainage area. Without a baffle, inflowing sediment goes directly to the riser and can pass through the slots. Figures A-6 through A-8 in the Appendix show the unobstructed flow path from the upland reach of the drainage area to the slotted riser.

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Samples of retained sediment were collected for grain size analysis at various locations in the basins. In Figures 2 through 7 the locations where the samples were collected are plotted. The grain size curves are in the Appendix, Figures A-2 through A-4.

Table 5 presents the soil classification of the retained sediment. The particle size ranges are based on the M.I.T. classification, except that the upper limit for the gravel-size particles was actually three inches instead of five millimeters [16]. The upper limit of three inches for gravels is based on the Unified Soil Classification System [17].

The adjective in the name of the soil sample represents the size range with the second highest percentage of particles, while the noun represents the size range with the highest percentage of particles. Because the soil is decomposed granite with little or no organic content and no plasticity, it is appropriate to call the "clay" range, "clay-size".

Most of the retained sediment is whitish, well graded, gravelly sand, with no cohesion and a texture like granulated sugar. Gravel larger than 3/4-inch was not transported to the basins. Silt-size particles were deposited near and in the low spots of the basins. Because there is cyclic removal and deposition of sediment within the basins, silt and clay-size sediment can be covered by or mixed with sands and gravels. Even though the slots are much larger than the sediment, a bridged network of sediment can form at the slots. However, the bridged network of sediment can be dislodged, and sediment as large as the smallest dimension of the slot can pass. See Section 5.4.2 for the discussion of "Passed Sediment".

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TABLE 5

SOIL CLASSIFICATION OF RETAINED SEDIMENT

Post Mile	Sample No.	Depth Range (inches)	Distance to Riser (feet)	D_{60} (microns) ***	D_{10} (microns) ***	Uniformity Coefficient D_{60}/D_{10}	Percentage* Clay	Percentage* Silt	Percentage* Sand	Percentage* Gravel	Typical Name	Gradation **	Remarks
66.69	1	0-3	30	900	44	20.5	1	12	67	20	gravelly SAND	W	flow line, upland
	2	0-3	15	2000	120	16.7	1	4	56	39	gravelly SAND	W	flow line, highway
	3	0-3	1	52	5	10.4	8	56	31	5	sandy SILT	--	adjacent riser
	5	0-3	27	900	11	81.8	4	16	60	20	gravelly SAND	W	coarse sediment
	6	6-12	27	450	8	56.3	5	22	56	17	silty SAND	W	overlaying fines
	7	0-1	10	22	<1	+22	17	68	15	0	clayey SILT	--	near low spot
	8	6-8	10	600	16	37.5	4	11	68	17	gravelly SAND	W	
66.75	1	0-1	9	32	3.1	10.3	6	85	9	0	sandy SILT	--	low spot
	2	0-3	7	1400	85	16.5	2	6	62	30	gravelly SAND	W	flow line, highway
	5	0-3	17	1550	74	20.9	1	7	59	33	gravelly SAND	W	flow line, highway
	6	0-1	11	130	3.8	34.2	5	46	40	9	sandy SILT	--	near low spot
66.84	1	0-3	20	900	6.8	132	5	28	41	26	silty SAND	W	near low spot
	2	0-3	4.5	3100	62	50	1	9	40	50	sandy GRAVEL	W	flow line, highway
	3	0-1	22	16	1.1	14.5	15	79	5	1	clayey SILT	--	low spot
	4	0-6	1	1000	30	33.3	8	12	52	28	gravelly SAND	W	adjacent riser
	5	0-3	20	1000	7.5	133.3	3	12	62	23	gravelly SAND	W	sediment fan
	6	0-1	14	75	2.8	26.8	8	50	31	11	sandy SILT	--	near low spot
70.66	1	0-6	2.5	1800	59	30.5	2	4	57	37	gravelly SAND	W	adjacent riser
	2	6-12	2.5	1900	30	60	2	5	56	37	gravelly SAND	W	
	3	0-3	20	2600	45	57.8	1	4	48	47	gravelly SAND	W	flow line, highway
	4	6-12	20	2050	60	34.2	1	4	55	40	gravelly SAND	W	
71.17	1	0-3	6	3000	150	20	1	4	42	53	sandy GRAVEL	W	flow line
	2	0-3	1	1500	60	25	2	7	58	33	gravelly SAND	W	adjacent riser
	3	0-3	5.5	1000	50	20	1	10	66	23	gravelly SAND	W	flow line
	4	6-12	5.5	1300	74	17.6	1	8	64	27	gravelly SAND	W	flow line
	5	0-3	3.5	750	40	18.8	0	13	72	15	gravelly SAND	W	near low spot
71.3[illegible]	1	0-3	5	1100	22	50	2	19	50	29	gravelly SAND	W	flow line, upland
	2	0-3	12	1050	74	14.2	1	7	72	20	gravelly SAND	W	flow line, highway
	3	0-3	12.5	1350	150	9	1	5	69	25	gravelly SAND	W	flow line, highway
	4	0-3	33	1500	74	20.3	1	8	58	33	gravelly SAND	W	scour channel, upland
	5	0-3	33	1350	60	22.5	1	9	65	25	gravelly SAND	W	fan, upland

NOTES: *M.I.T. Classification: (G. Gilboy, 1931) clay is 2 microns and smaller, silt is 2 to 60 microns, sand is 60 to 2000 microns, gravel is 2000 microns to 5.0 millimeters.

**The gradation descriptor, "W" means well graded, when the uniformity coefficient is greater than 6 for sands and greater than 4 for gravels, according to the Unified Soil Classification System.

***D_{60} is the effective grain diameter of which 60% of the soil particles are finer and 40% are coarser than the effective diameter. Similarly, D_{10} is the effective grain diameter of which 10% of the soil particles are finer and 90% are coarser than the effective diameter.

In Figures 2 through 4, 6 and 7, the low spots are not at the slotted risers. As sediment deposits near the risers, a fan develops, and the low spot migrates away from the riser. When the low spot is not at the riser, more time is available for sedimentation. Because the sediment is mostly sand, any water in the basins infiltrated rapidly or seeped to the riser and drained through the slots.

5.4.2 Passed Sediment

Samples of sediment-laden runoff which passed through the basins were collected in 5 gallon buckets at the culvert outlets during the two January storm periods. The buckets were placed before the storms and were collected after rainfall ceased. The outlet was submerged at post mile 70.66 by high water in Little Grass Valley Creek. Consequently, no sample was collected there during the January 26,27 storm.

Grain size curves of the passed sediment are included with the grain size curves of retained sediment in Figures A-2 through A-4 in the Appendix.

Table 6 presents the soil classification of the passed sediment samples. The rules used for classifying and naming the samples of passed sediment were the same as those for the retained sediment.

The sediment that passed through was sandy gravel, gravelly sand, and silty sand. Because the samples were not collected continuosly at frequent intervals of volume or time, the total amount of sediment which was discharged to Little Grass Valley Creek was not calculated. However, based on the measurements of retained sediment

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TABLE 6

SOIL CLASSIFICATION OF PASSED SEDIMENT

Post Mile	D_{60} (microns) ***	D_{10} (microns) ***	Uniformity Coefficient D_{60}/D_{10}	Percentage * Clay	Silt	Sand	Gravel	Typical Name	Gradation **	Sample Collection (date)	Dry Weight of Sediment (pounds)	Remarks
66.69	2300	5	460	1	12	33	54	sandy GRAVEL	W	Jan. 27, 1983	1.1	
66.75	1020	74	13.8	0	9	72	19	gravelly SAND	W	Jan. 17, 1983	0.1	found in bucket before storm
	590	74	8.0	1	9	86	4	silty SAND	W	Jan. 19, 1983	0.4	
	1900	150	12.7	0	5	55	40	gravelly SAND	W	Jan. 27, 1983	1.7	
66.84	3000	95	31.6	1	9	40	50	sandy GRAVEL	W	Jan. 19, 1983	5.9	
	4000	190	21.1	0	5	35	60	gravelly SAND	W	Jan. 27, 1983	0.7	
71.17	3050	74	41.2	0	9	40	51	sandy GRAVEL	W	Jan. 27, 1983	13.0	basin full of sediment
71.36	2700	100	27	1	6	45	48	sandy GRAVEL	W	Jan. 19, 1983	4.4	basin full of sediment

NOTES: *M.I.T. Classification = Clay is 2 microns and smaller, silt is 2 to 60 microns, sand is 60 to 2000 microns, (G. Gilboy, 1931) gravel is 2000 microns to 5.0 millimeters.

**The gradation descriptor "W", means well graded, when the uniformity coefficient is greater than 6 for sands, and greater than 4 for gravels, according to the Unified Soil Classification System.

***D_{60} is the effective grain diameter of which 60% of the soil particles are finer and 40% are coarser than the effective diameter. Similarly, D_{10} is the effective grain diameter of which 10% of the soil particles are finer and 90% are coarser than the effective diameter.

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and the observations during the storms, it appears that the amount of passed sediment is much less than the amount of retained sediment.

The bridged network of sediment at the slots can be dislodged by inflows which go directly to the riser. Consequently, sediment particles as large as the smallest dimension of a slot can pass through. Generally during low flows there is not enough energy to dislodge the interlocked particles of sediment. Figure A-18 in the Appendix shows scour adjacent the riser at post mile 66.84. In addition, concentrated inflows can scour sediment already deposited in the basins. Figure A-8 in the Appendix shows a scoured inflow path at post mile 66.69.

Because the basins at post miles 70.66, 71.17, and 71.36 were full of sediment, particles as large as the culvert diameter could pass. However, since the sediment was mostly sand, only an occasional 3/4-inch gravel particle passed through. Sediment larger than 3/4-inch was not found in the basins.

Some samples were collected at the culvert outlets for total residue testing. Table 7 displays the results of total residue tests, instantaneous outlet flow rates, and the instantaneous rates of sediment discharge. The samples collected on January 24, 1983 did not contain sediment particles larger than 297 microns. This was verified by holding a US 50 sieve (297 microns) at the culvert outlet. These samples characterize flow through the slots during seepage conditions in the basins, except as noted in the "Remarks" column.

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TABLE 7

PASSED SEDIMENT, TOTAL RESIDUE

Post Mile	Date (1983)	Outlet Flow Rate* l/s	Total Residue mg/l	Rate of Sediment Discharge* mg/s	pound/s	Remarks
66.69	Jan. 24	0.0228	185	4.22	9.3×10^{-6}	Steady, seepage flow
66.75	Jan. 24	0.0841	55	4.63	1.02×10^{-5}	unsteady seepage flow, 3-10 second surges
66.84	Jan. 24	0.0398	172	6.85	1.51×10^{-5}	steady, seepage flow
70.66	Jan. 24	0.0591	104	6.15	1.36×10^{-5}	steady, seepage flow
71.17	Jan. 24	0.0676	152	10.30	2.27×10^{-5}	steady, seepage flow
71.36	Jan. 24	1.35	311	420.	9.27×10^{-4}	steady, seepage flow over riser lip
70.66	Jan. 26	5.05	2670	13,484	2.97×10^{-2}	near peak runoff, flow over riser lip
66.69	Jan. 26	6.309	162	1022	2.25×10^{-3}	near peak runoff, reddish brown silt
66.69	Jan. 26	0.742	113	83.8	1.85×10^{-4}	receding runoff

*Instantaneous

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Sediment smaller than 297 microns is part of the wash load. The wash load is transported downstream and is not retained in the gravel spawning beds.

Three total residue samples were collected on January 26, 1983 at post miles 66.69 and 70.66. The "Remarks" in Table 7 state that two of the samples were collected near peak runoff. The last entry in Table 7 is typical of receding runoff. At post mile 66.69 the sediment was sandy gravel mixed with a reddish brown silt, unlike the sediment at the other basins.

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6.0 REFERENCES

1. Howell, Richard B.; Nakao, Don I.; Parks, Douglas M; Sediment Accumulation at Highway Culverts Modified With a Slotted Pipe Riser on Inlet, California Department of Transportation, CA/TL-80/25, June, 1980.

2. Personal communication between Bob McBroome (Caltrans District 02, Hydraulics) and Jim Racin (Caltrans TransLab) June, 1984.

3. California Department of Transportation, Highway Design Manual, California Department of Transportation, 7-821.9 (4), April 2, 1979.

4. California Division of Highways, California Culvert Practice, second edition, California Division of Highways, 1944, pp. 19 and 21.

5. Reihsen, G., Bureau of Public Roads, Region 7, Hydraulic Engineering Circular No. 9, "Debris Control Structures", Bureau of Public Roads, Washington, D.C., Feb., 1964, Plates VII-X, pp. 9-33 to 9-36.

6. California Department of Transportation, Standard Plans, California Department of Transportation, Plan D93, July 1980.

ClibPDF - www.fastio.com

6. REFERENCES (continued)

7. Personal communication between Jim Ross (Caltrans District 04) and Rich Howell (Caltrans TransLab) January 19, 1983.

8. Transportation Research Board, Design of Sediment Basins - NCHRP Synthesis 70, Transportaton Research Board, June 1980.

9. National Oceanic and Atmospheric Administration, Climatological Data Annual Summary California 1982 Vol. 86 No. 13, National Climatic Data Center, Asheville, North Carolina.

10. California Department of Water Resources, Water Conditions in California Report 4 May 1981, California Cooperative Snow Surveys Bulletin No. 120-81, Sacramento, California, 1981.

11. California Department of Water Resources, Water Conditions in California Report 4 May 1982, California Cooperative Snow Surveys Bulletin No. 120-82, Sacramento, California, 1982.

12. California Department of Water Resources, Water Conditions in California Report 1 February, 1983, California Cooperative Snow Surveys Bulletin No. 120-83, Sacramento, California, 1983.

ClibPDF - www.fastio.com

6. REFERENCES (continued)

13. National Oceanic and Atmospheric Administration,

Climatological Data California January 1983 Vol. 87 No. 1,

National Climatic Data Center, Asheville, North Carolina.

14. National Oceanic and Atmospheric Administration,

Storm Data

Volume 25, NO. 1, January 1983,

National Climatic Data Center, Asheville, North Carolina

15. California Department of Transportation,

Office of Computer Systems,

HIDES Highway Design System,

California Department of Transportation, Sacramento, Ca., April, 1980.

16. Casagrande, Arthur,

Transactions of the American Society of Civil Engineers,

Volume 113, American Society of Civil Engineers,

New York, 1948, pp. 901-991.

17. Yoder, E.J. and Witczak, M.W.,

Principles of Pavement Design, second edition,

John Wiley and Sons, Inc., New York, 1975, p. 238.

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ERRATA

This sheet replaces pages 36 and 37

7. APPENDIX

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7. APPENDIX (continued)

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7. APPENDIX

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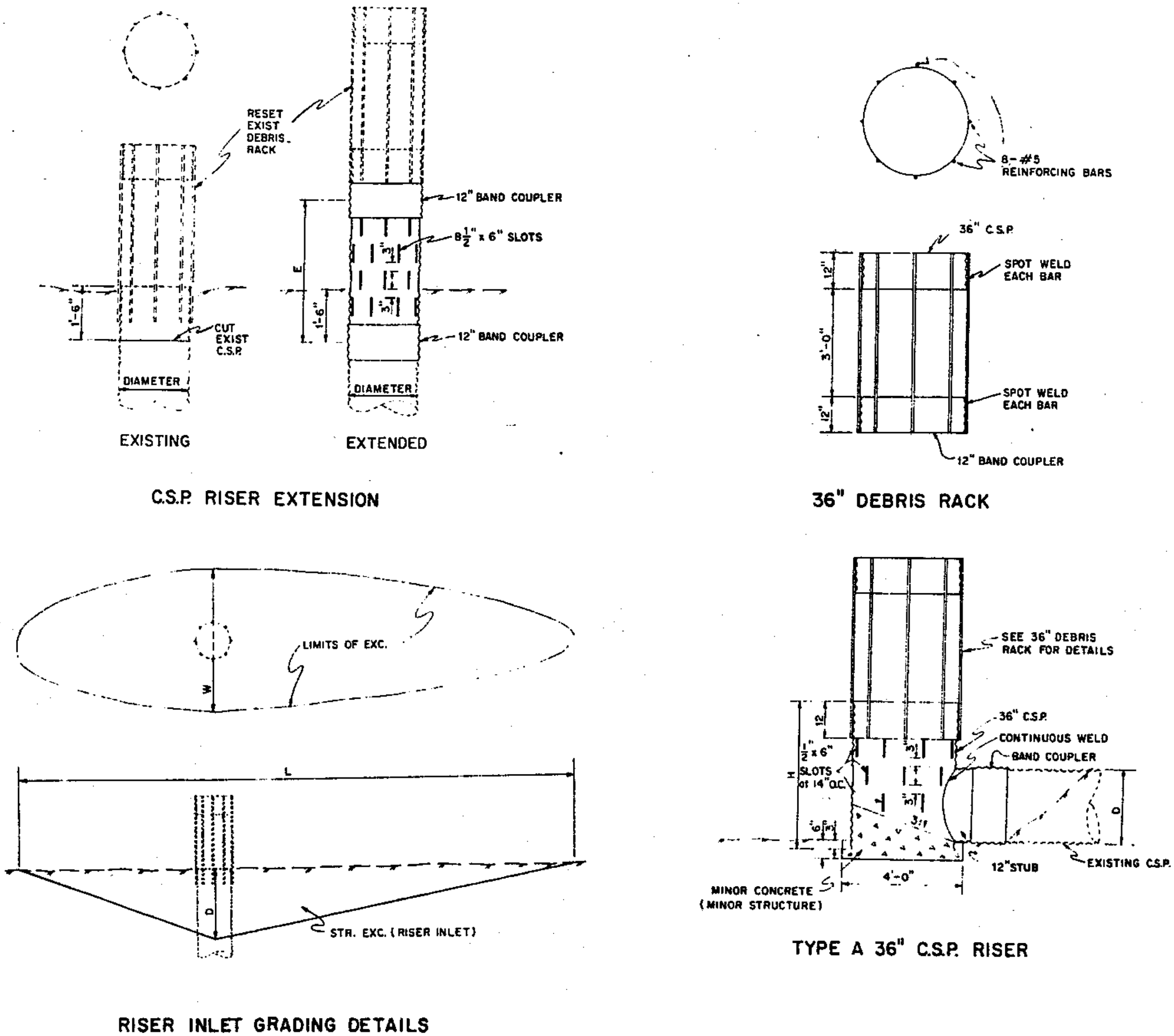

Figure A-1: C.S.P. Riser Extension, Riser Inlet Grading Details, Debris Rack, and Drop Inlet Riser Connection

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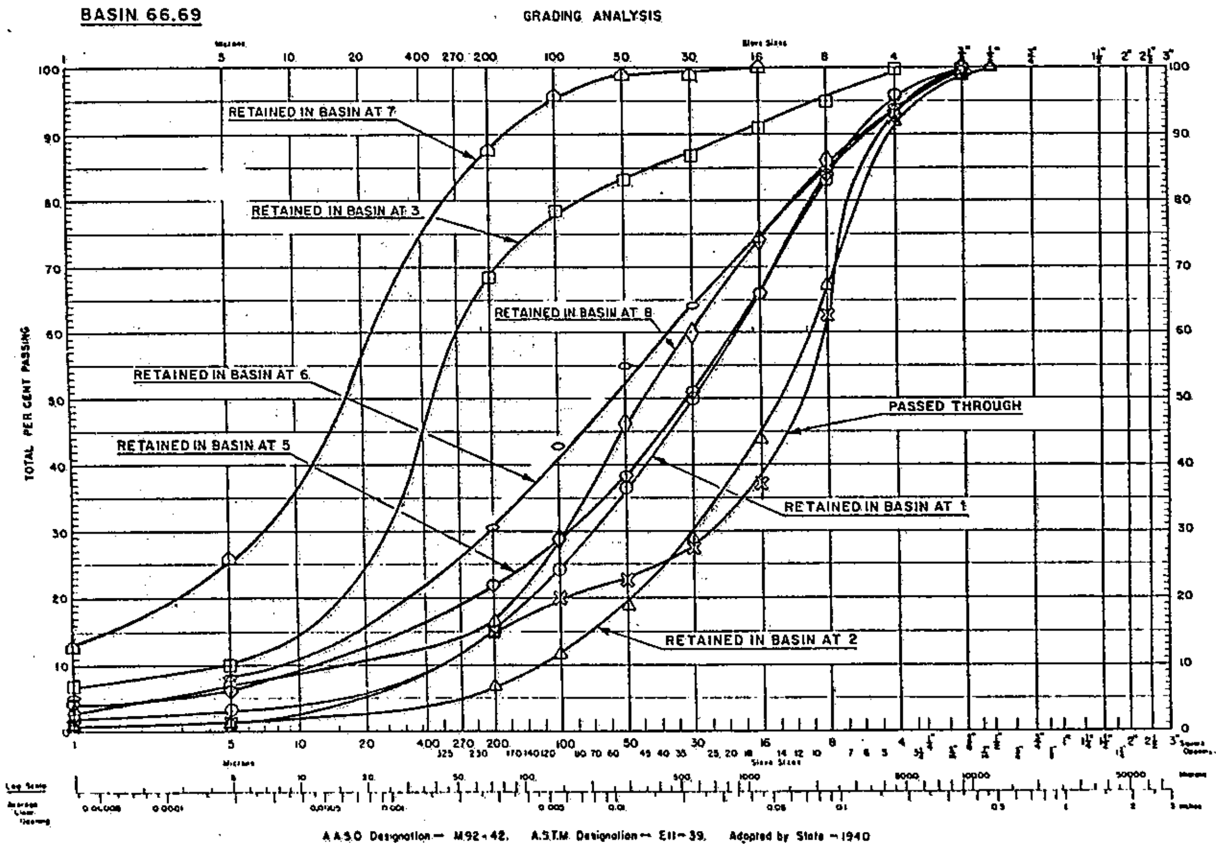

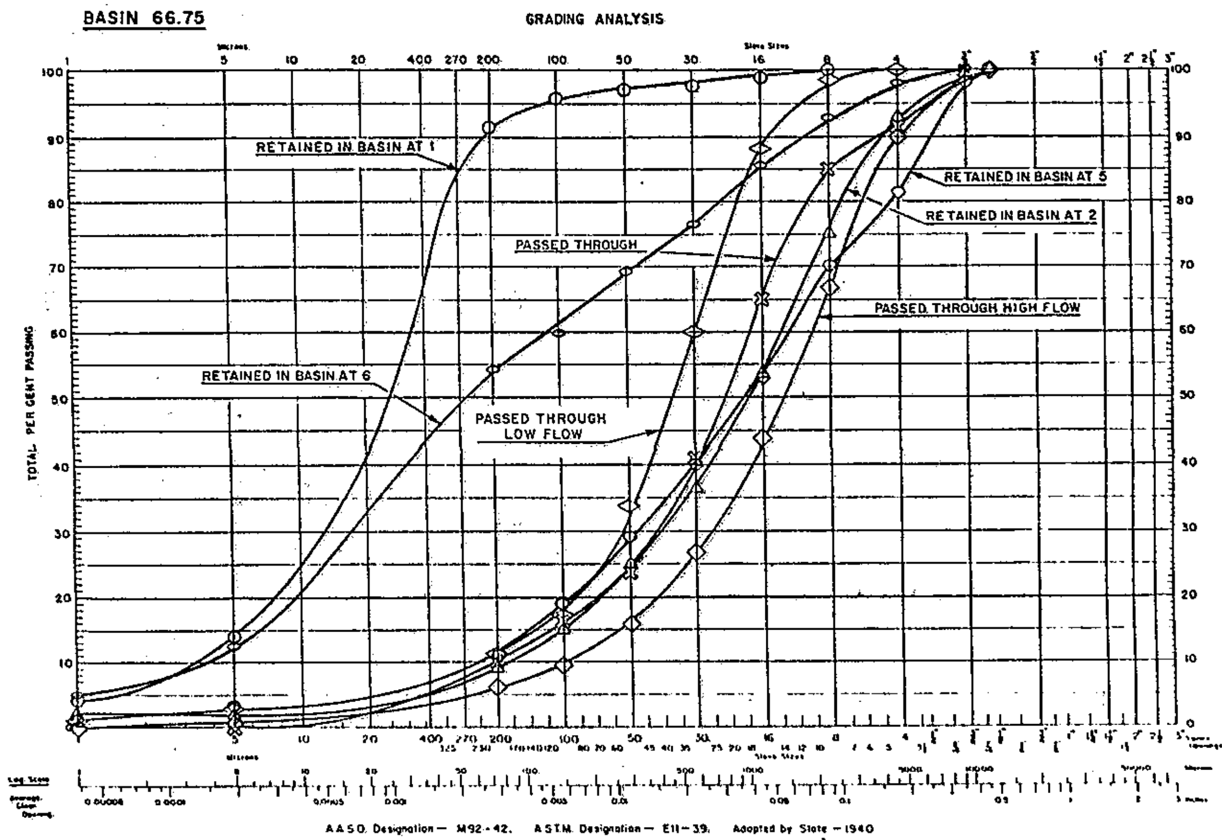

Figure A-2 : Grain Size Curves ; Post Miles 66.69 and 66.75

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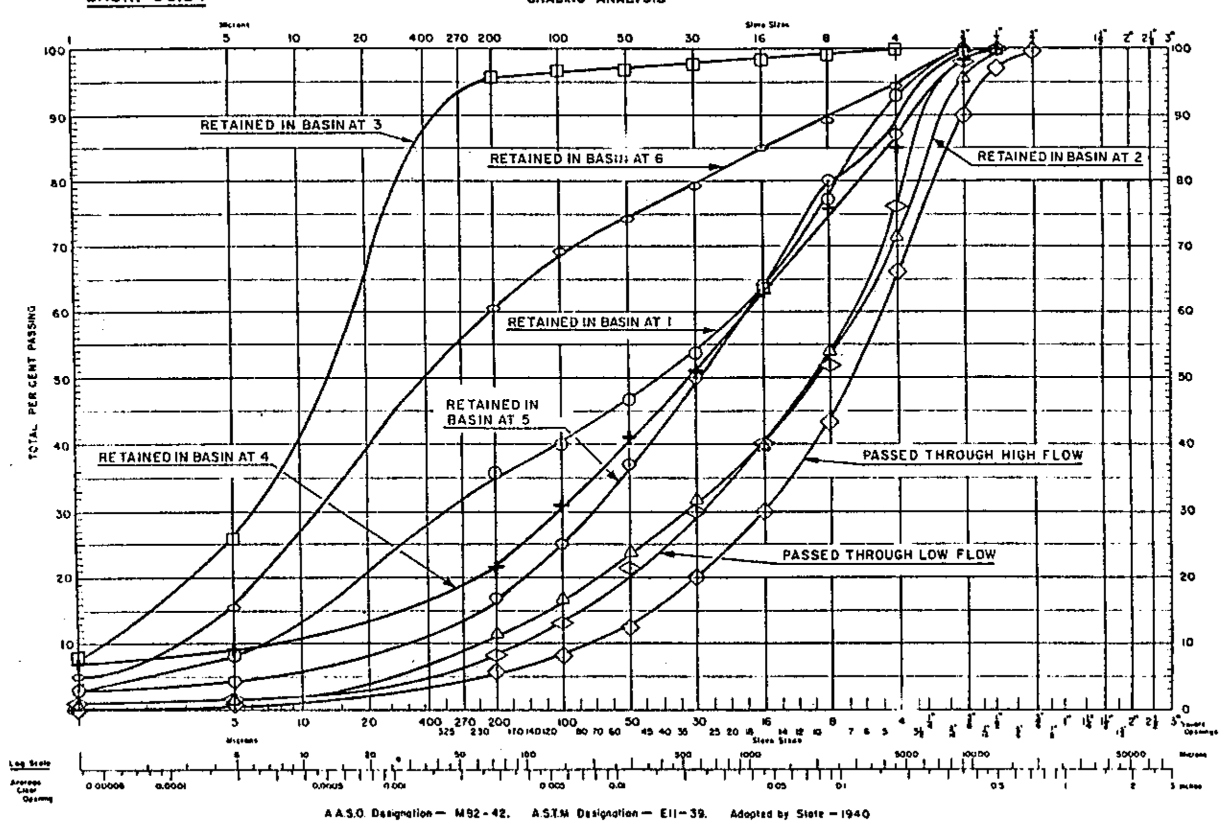
BASIN 66.84

GRADING ANALYSIS



BASIN 70.66

GRADING ANALYSIS

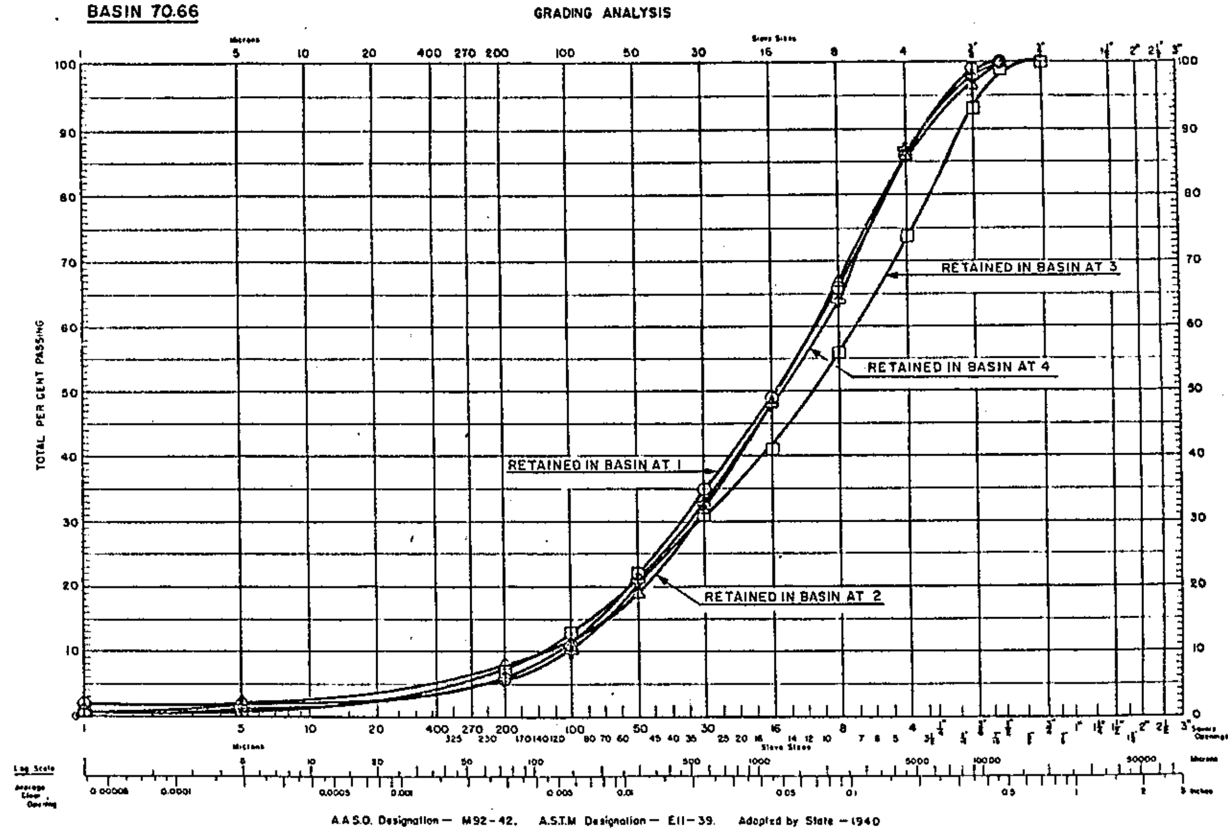


Figure A-3 : Grain Size Curves : Post Miles 66.84 and 70.66

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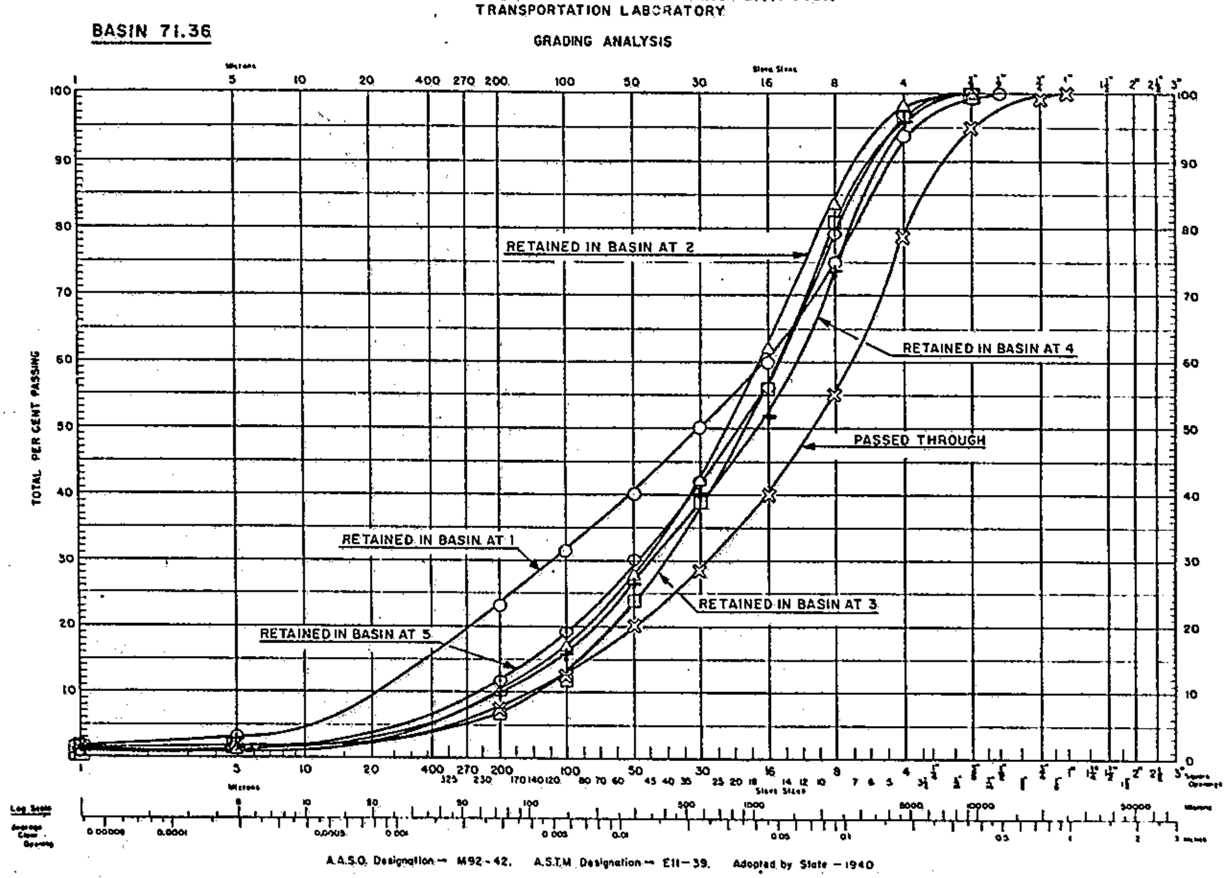

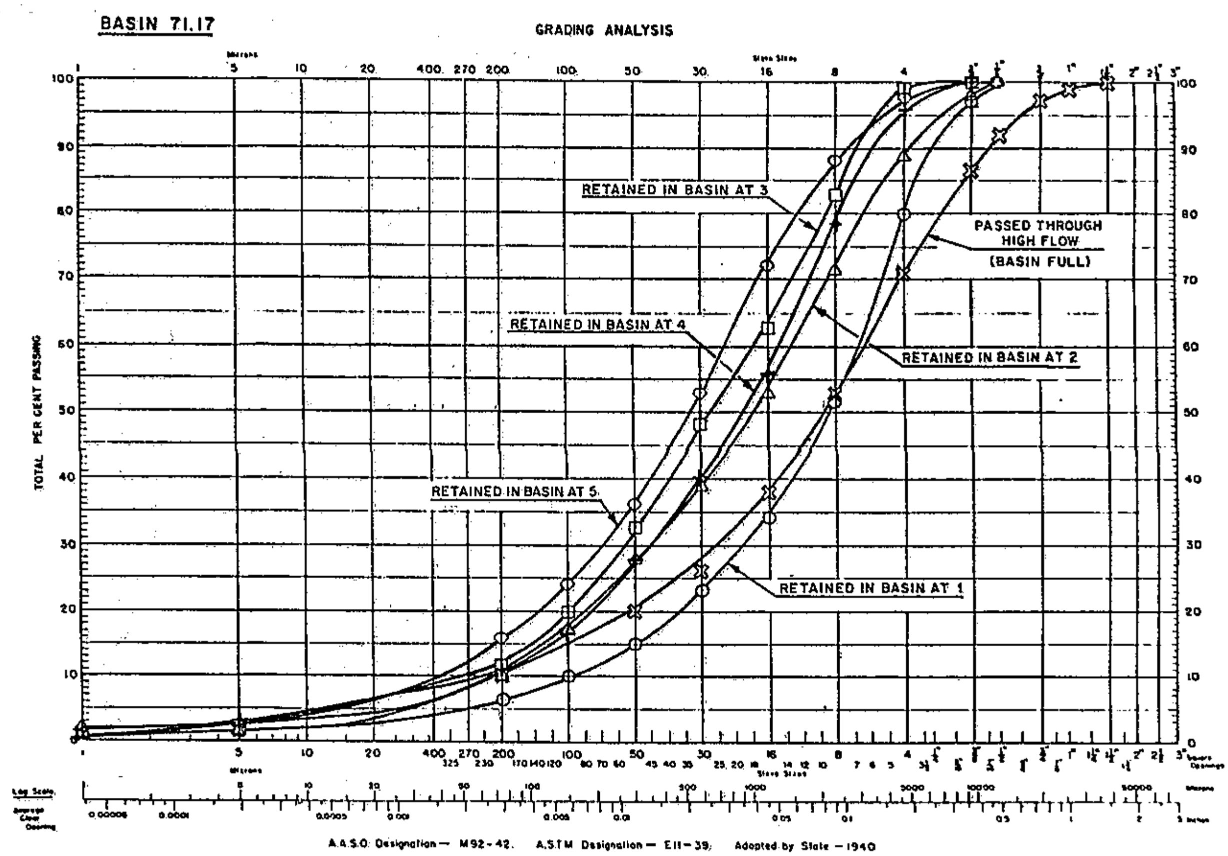

Figure A-4 : Grain Size Curves : Post Miles 71.17 and 71.36

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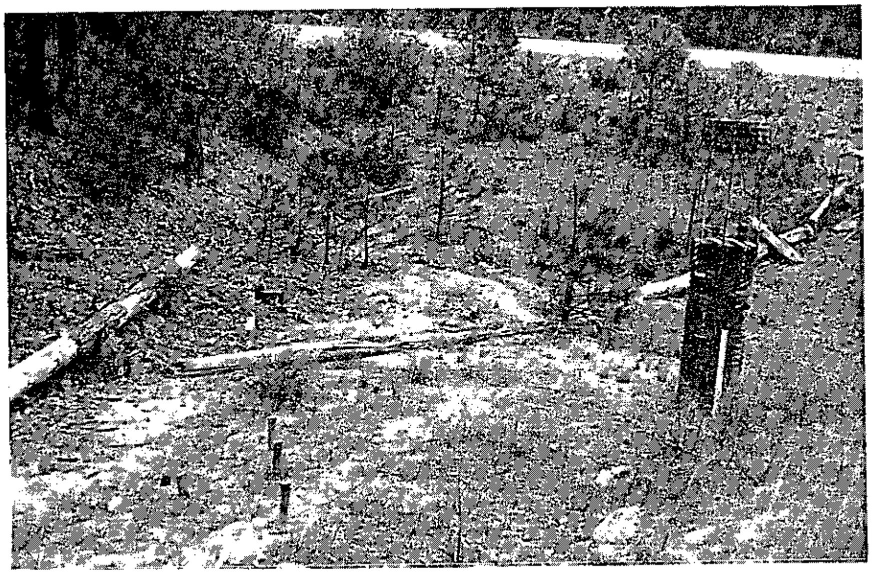
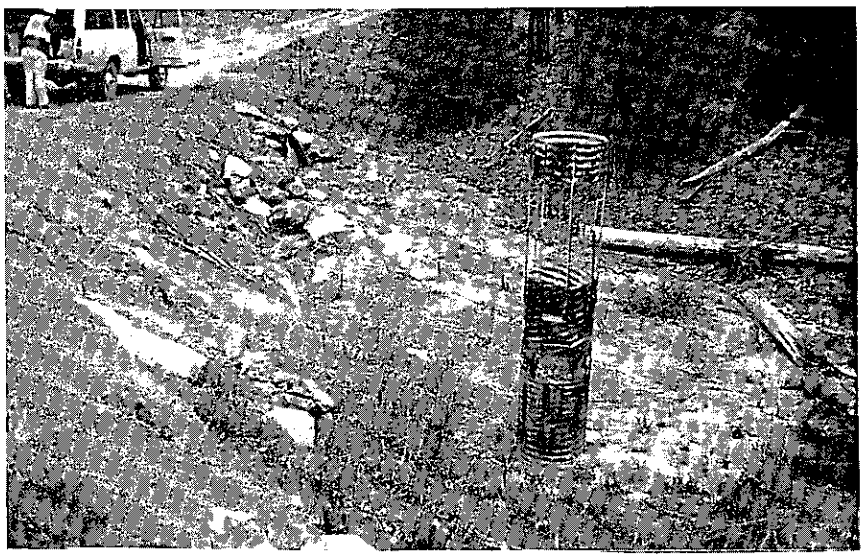


A-5-1
5/7/80



A-5-2
5/7/80

Figure A- 5, Site 1 Post Mile 66.69

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A-6-1
1/18/83
2 year storm

A-6-2
1/18/83

A-6-3
1/18/83
Scour path
from
upland inflow

Figure A-6, Site 1 Post Mile 66.69

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A-7-1
1/24/83
Seepage flow

A-7-2
1/24/83
Low spot behind riser

Figure A-7, Site 1 Post Mile 66.69

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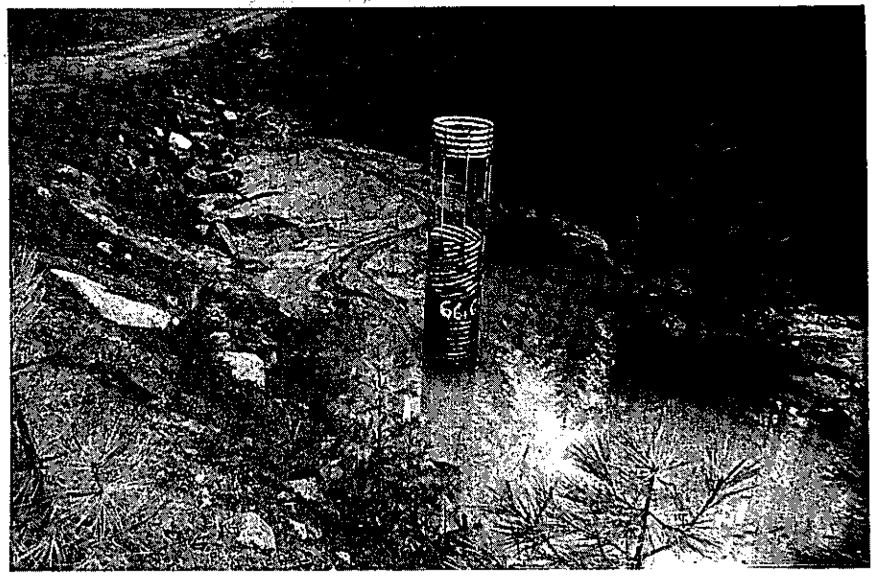
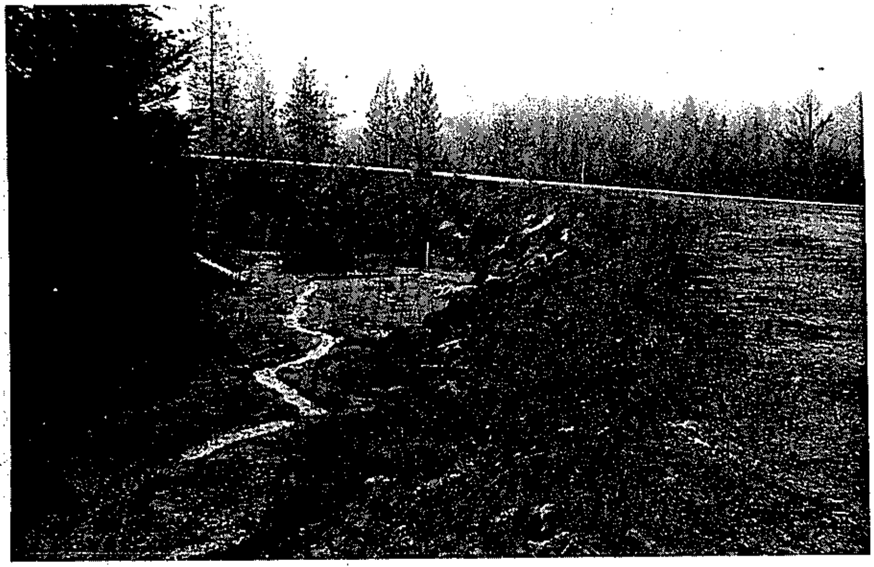
A-8-1
1/26/83
100 year storm



A-8-2
1/27/83
Receding flow



A-8-3
1/27/83
Scour path
from
upland inflow

Figure A-8, Site 1 Post Mile 66.69

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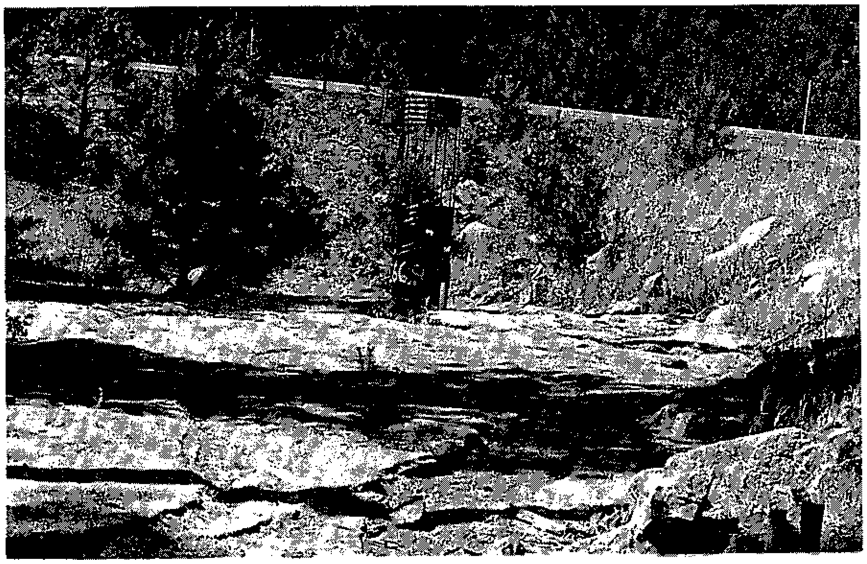
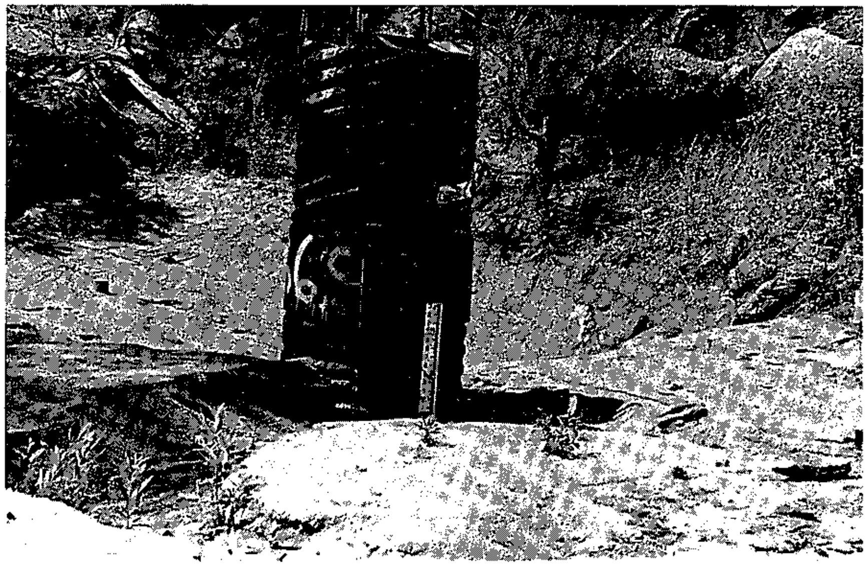
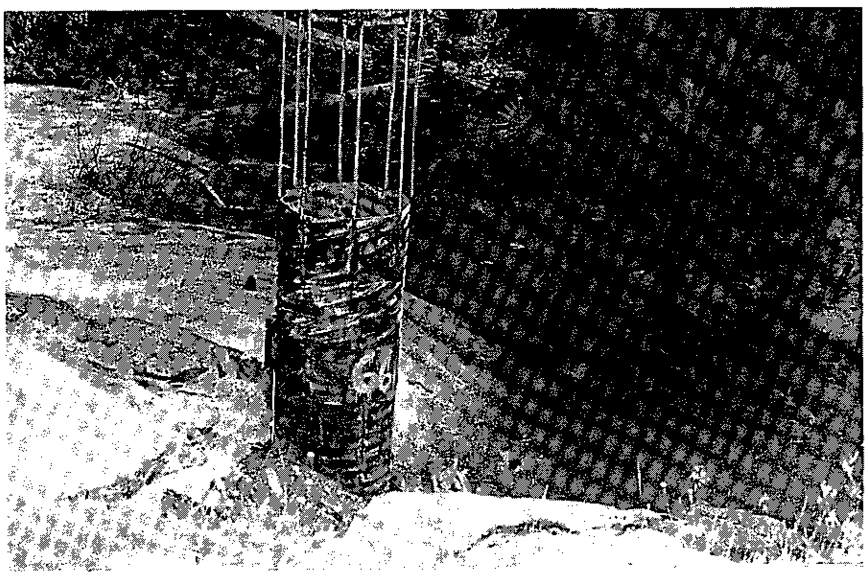


A-9-1
6/83

A-9-2
6/83
Low spot
behind riser





A-9-3
6/83
Upland
sediment

Figure A-9, Site 1 Post Mile 66.69

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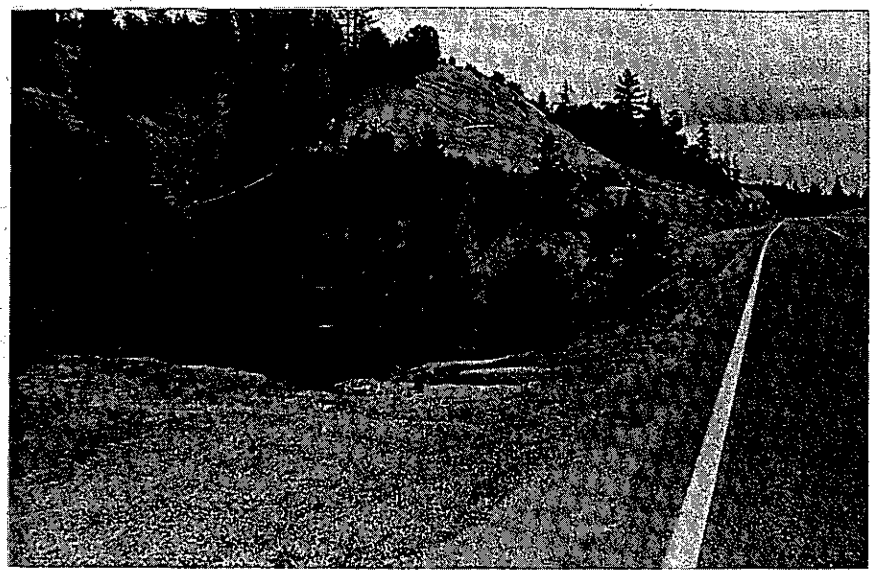

A-10-1
5/23/79

A-10-2
5/7/80

A-10-3
5/7/80

Figure A-10, Site 2 Post Mile 66.75

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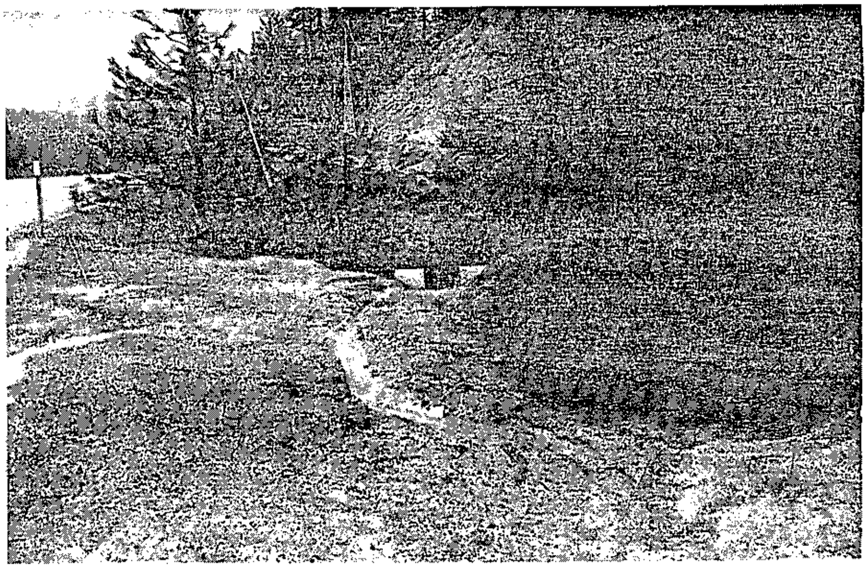
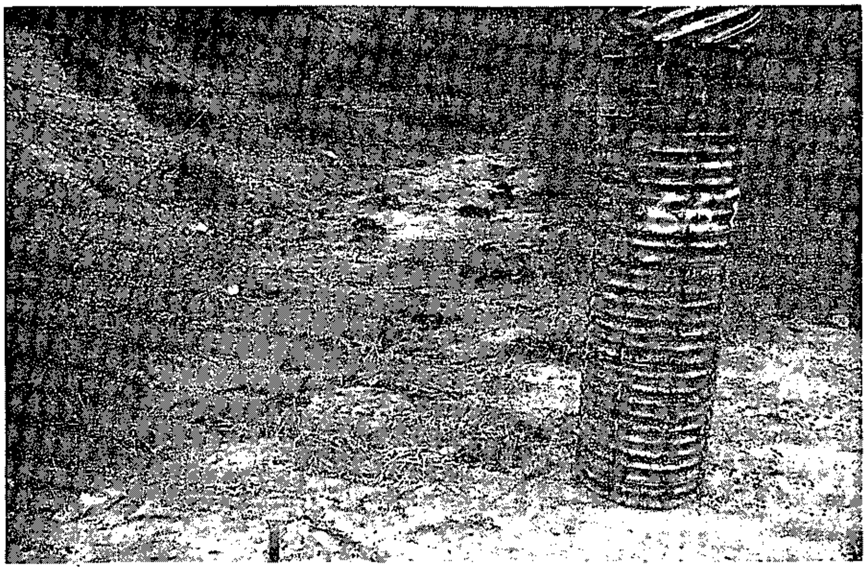


A-11-1
1/18/83
2 year storm

A-11-2
1/18/83
Scour from
flume
downdrain



A-11-3
1/18/83
Sediment fan
and
Low spot

Figure A-11, Site 2 Post Mile 66.75

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A-12-1
1/18/83 Erosion of Basin sides

A-12-2
1/24/83 Seepage Flow

Figure A-12 Site 2 Post Mile 66.75

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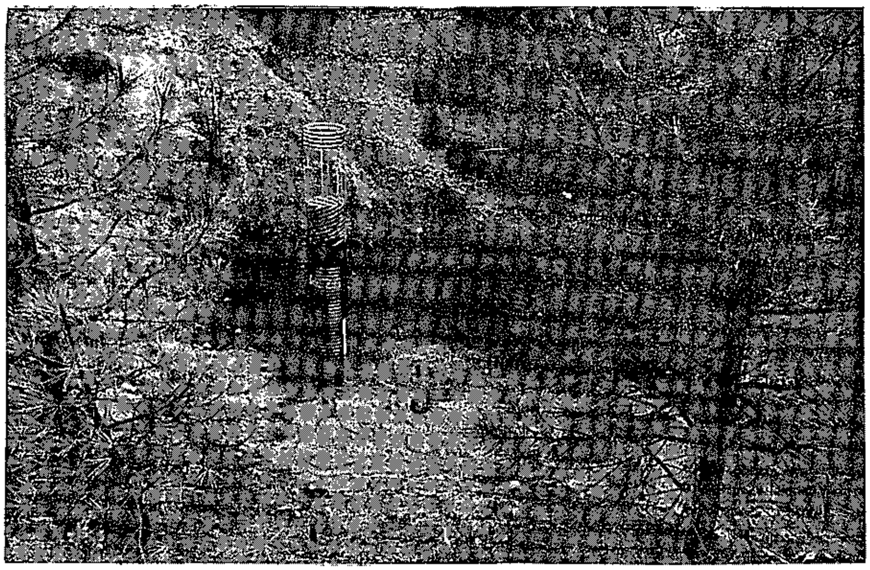
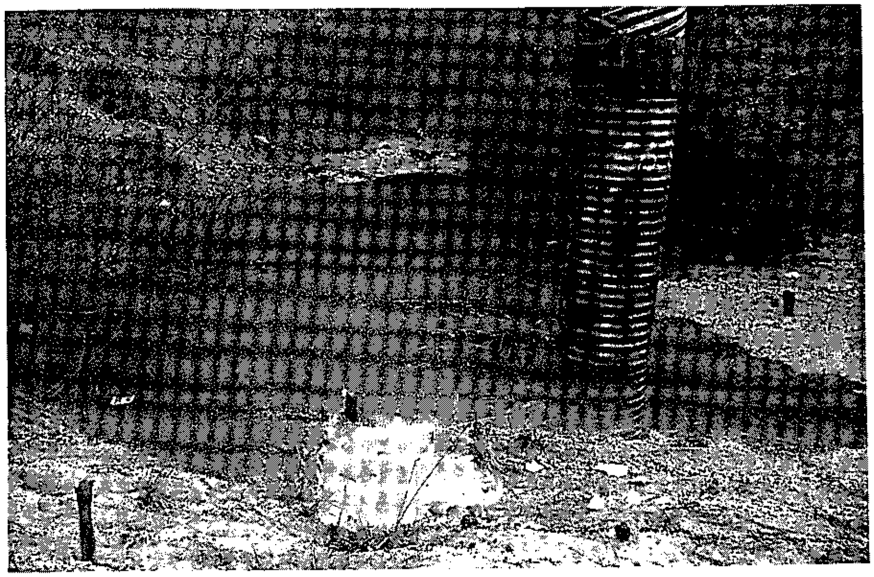
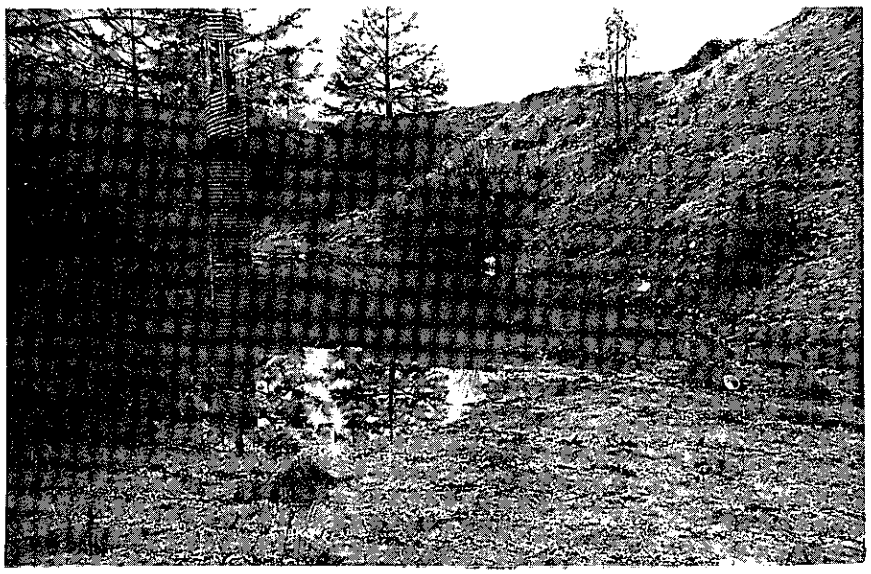


A-13-1
1/27/83
Day after
100 year
storm



A-13-2
1/27/83
Sediment fan
building by
Riser



A-13-3
1/27/83
View from
upland
inflow path

Figure A-13, Site 2 Post Mile 66.75

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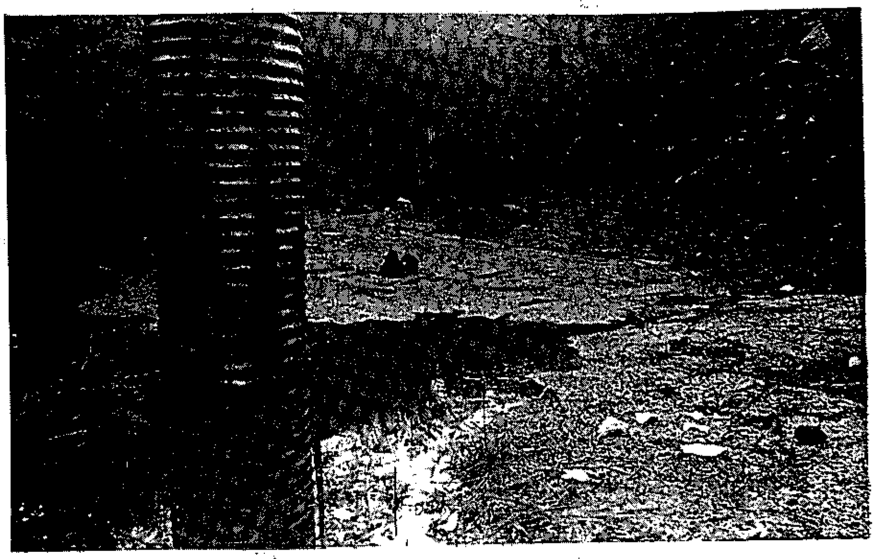

A-14-1
1/27/83
Sediment from flume
downdrain

A-14-2
6/83
Upland
Sediment
view from
highway

Figure A-14, Site 2 Post Mile 66.75

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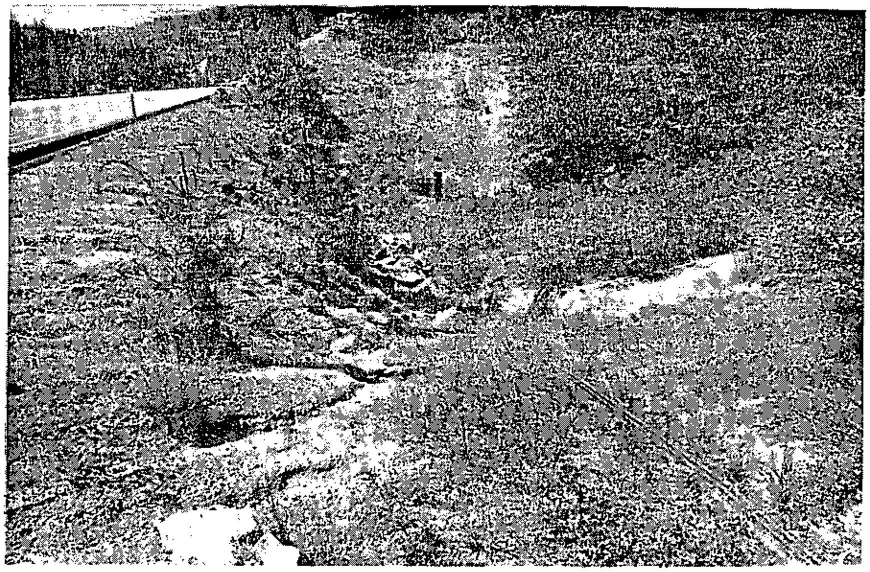
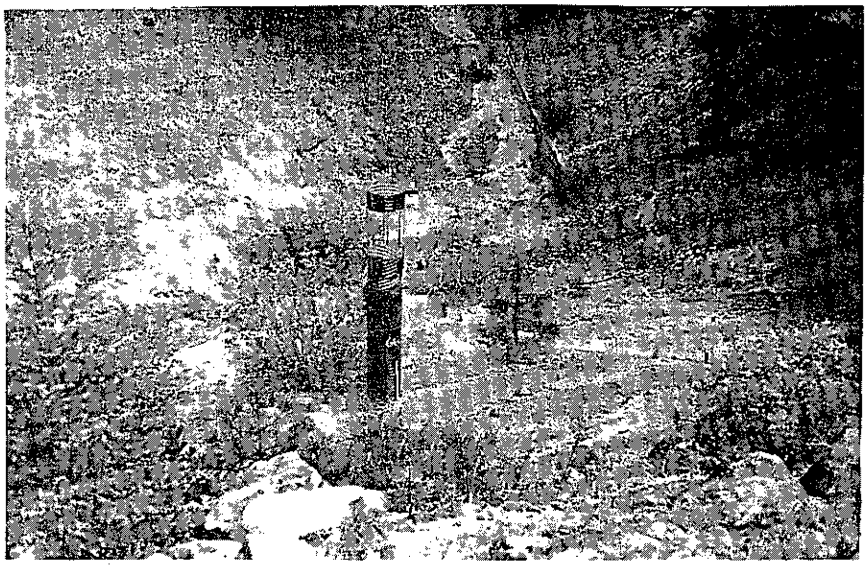
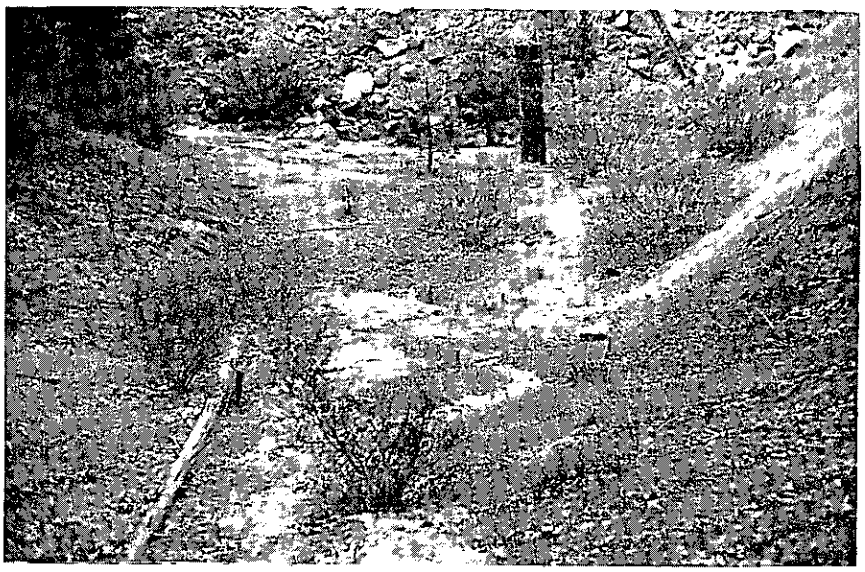


A-15-1
5/23/79

A-15-2
5/7/80





A-15-3
5/7/80

Figure A-15, Site 3 Post Mile 66 84

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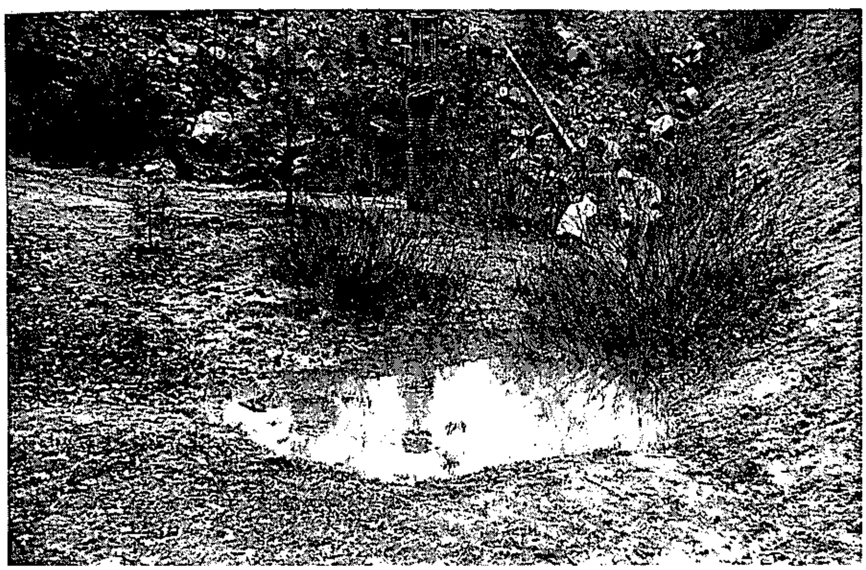
A-16-1
1/18/83
2 year storm

A-16-2
1/18/83
Upland
sediment
inflow



A-16-3
1/18/83
Low spot

Figure A-16, Site 3 Post Mile 66.84

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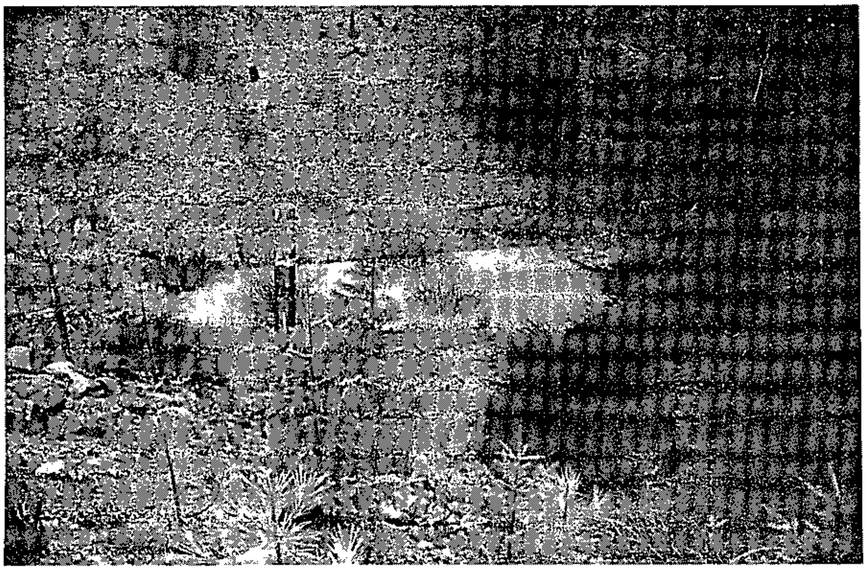
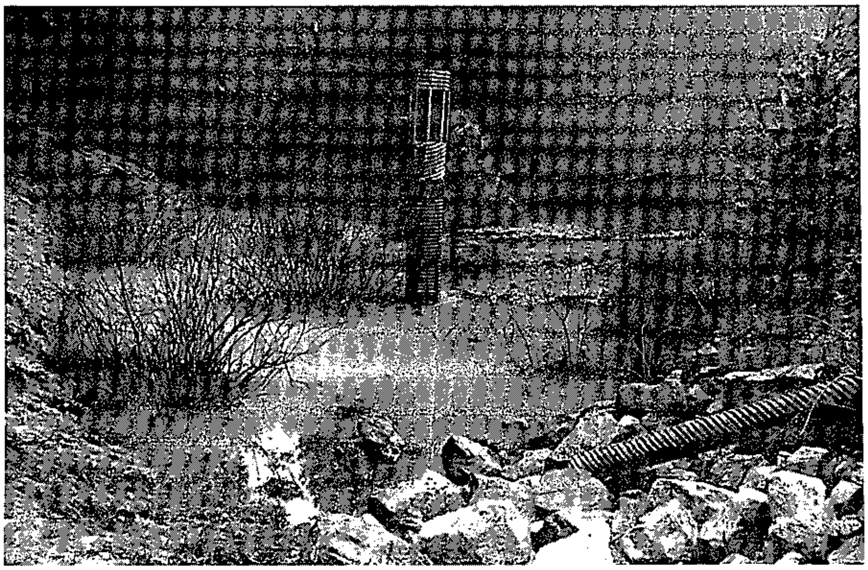


A-17-1
1/26/83
100 year storm



A-17-2
1/27/83 Receding runoff

Figure A-17, Site 3 Post Mile 66.84

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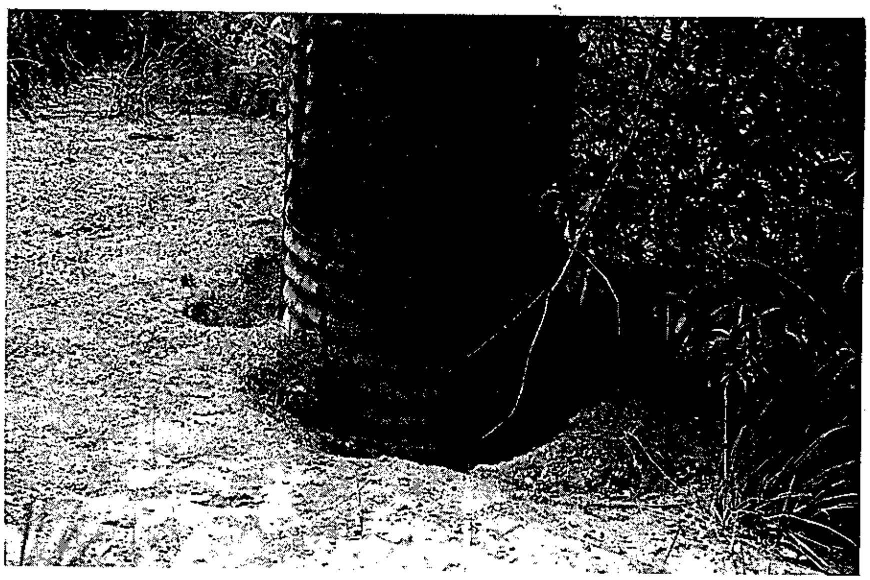
A-18-1
6/83
Scour adjacent riser



A-18-2
6/83
Scour adjacent riser

Figure A-18, Site 3 Post Mile 66.84

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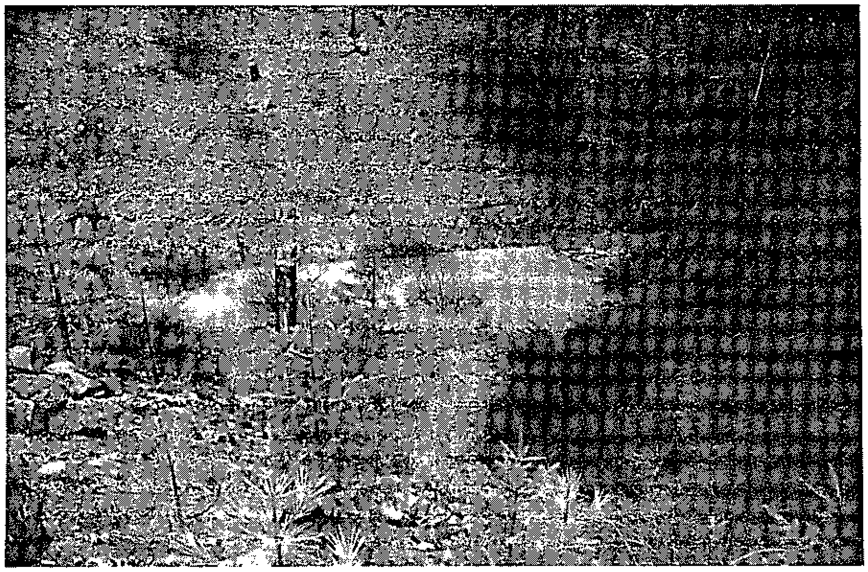
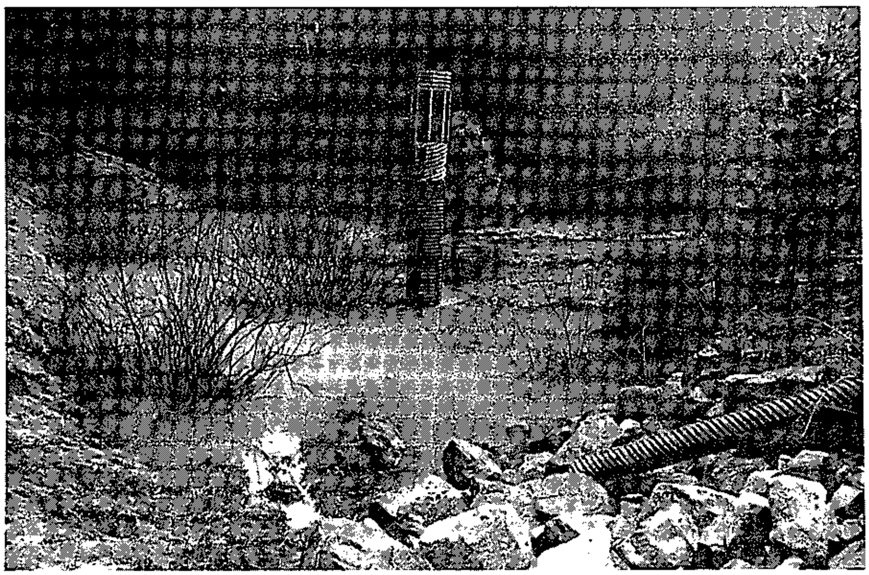


A-17-1
1/26/83
100 year storm



A-17-2
1/27/83 Receding runoff

Figure A-17, Site 3 Post Mile 66.84

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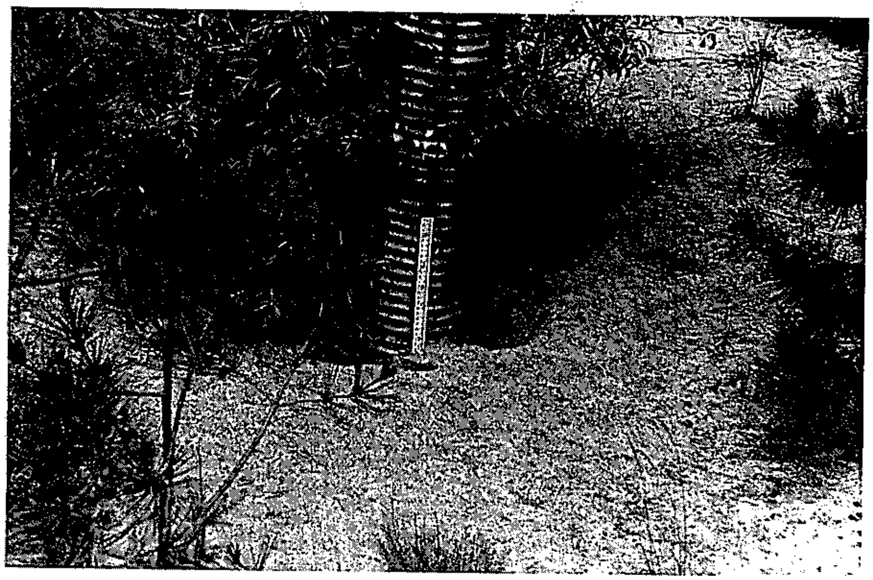
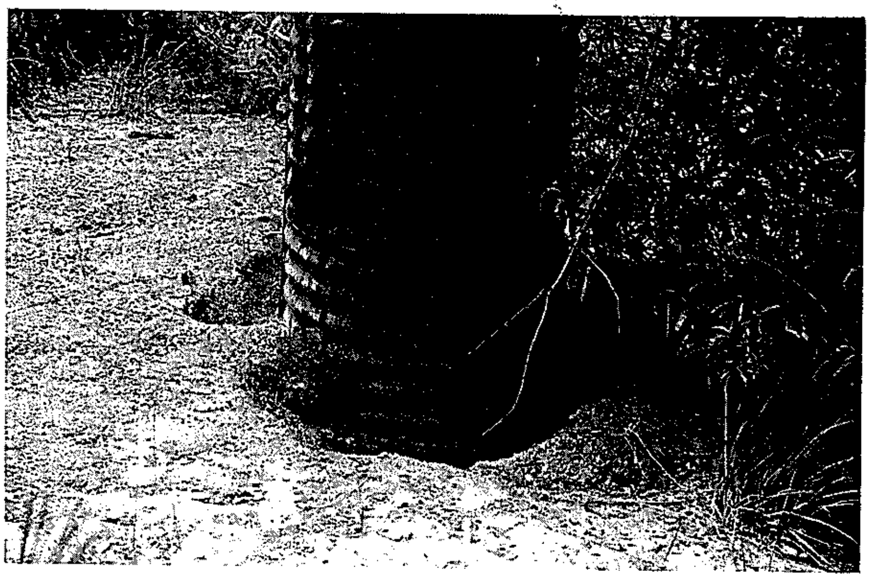


A-18-1
6/83
Scour adjacent riser



A-18-2
6/83
Scour adjacent riser

Figure A-18, Site 3 Post Mile 66.84

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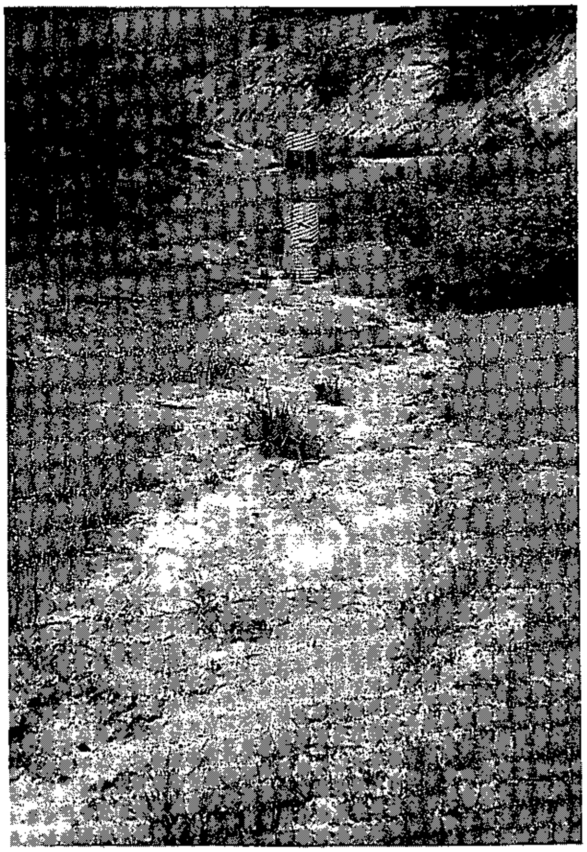
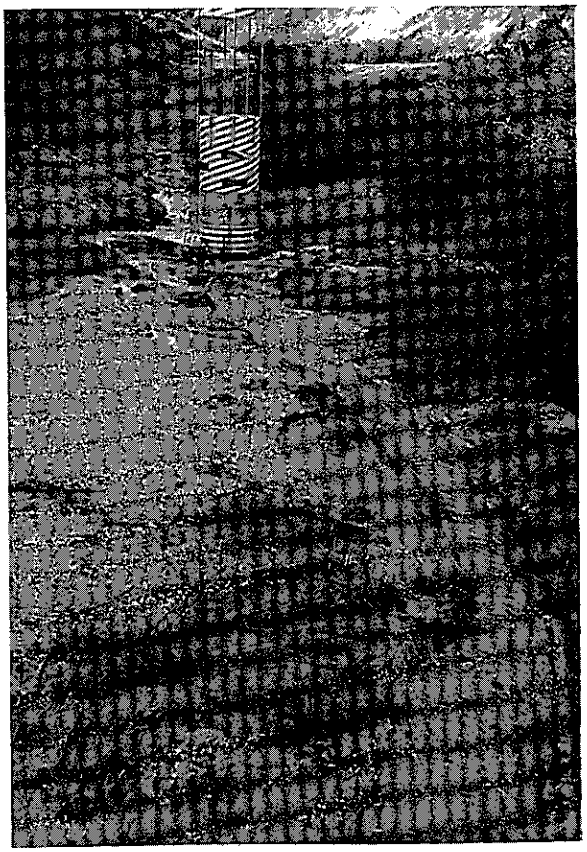


A-19-1
5/23/79
9 inch by 3 inch
slots



A-19-2
2/21/80
Runoff and Sediment
going directly
through slot

Figure A-19, Site 4 Post Mile 67.72

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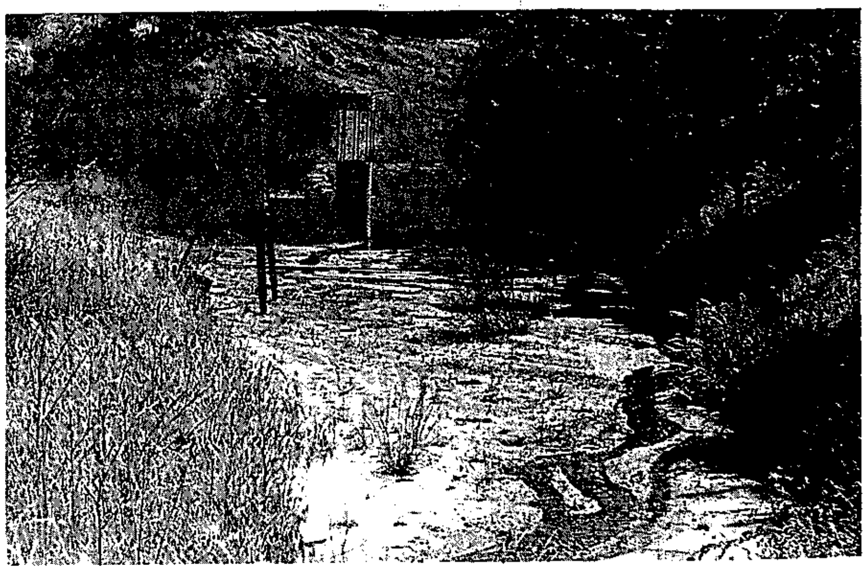
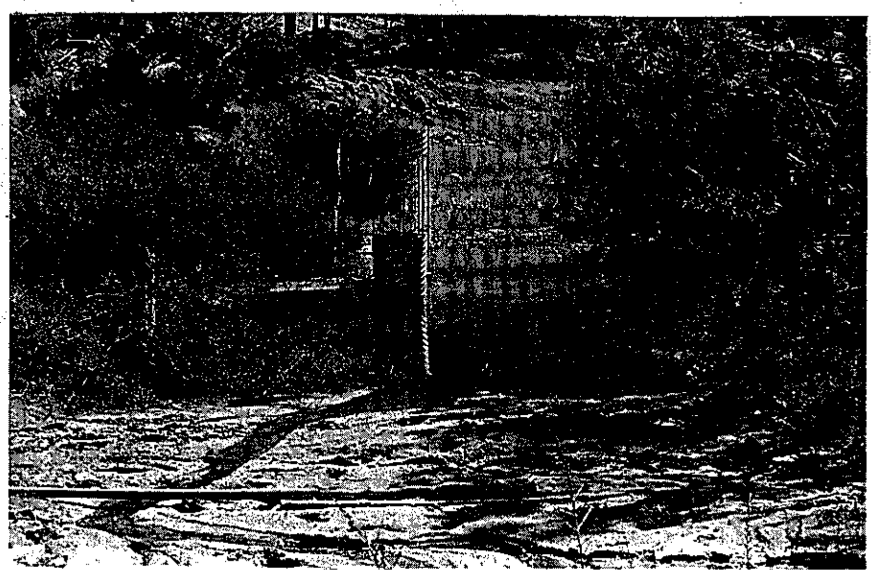
A-20-1
6/83
Large slot plugged 0.5 foot depth at riser

A-20-2
6/83
Scoured flow path





A-20-3
6/83

Figure A-20, Site 4 Post Mile 67.72

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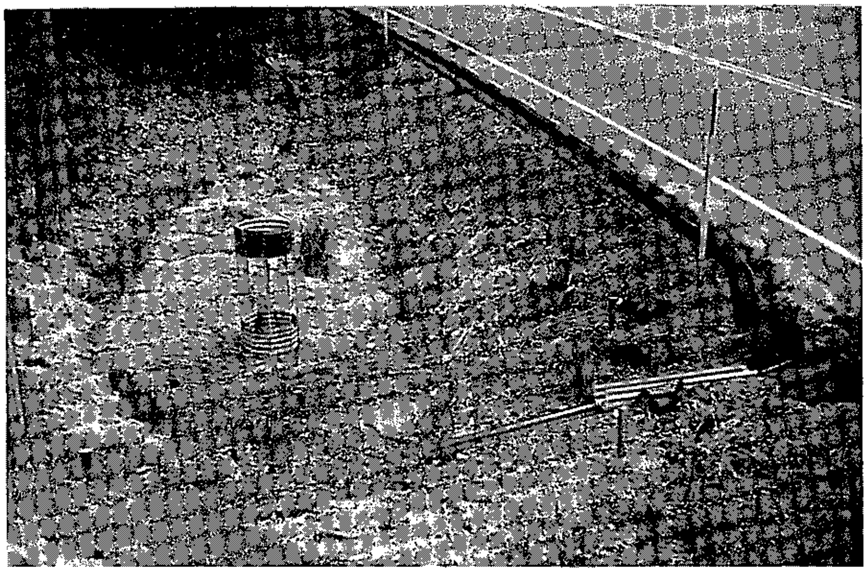
A-21-1
2/21/80



A-21-2
5/7/80

A-21-3
5/7/80

Figure A-21, Site 5 Post Mile 70.66

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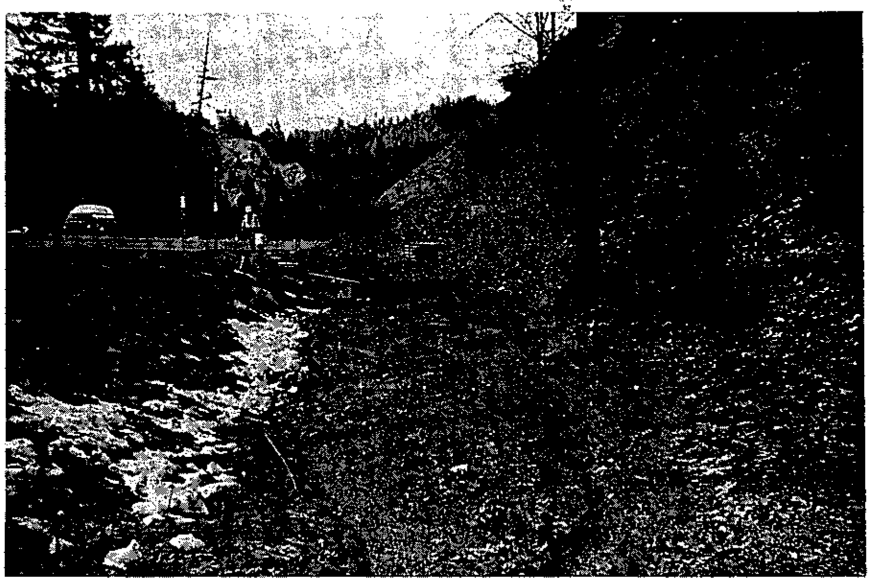

A-22-1
1/24/83

A-22-2
1/24/83

Figure A-22, Site 5 Post Mile 70.66

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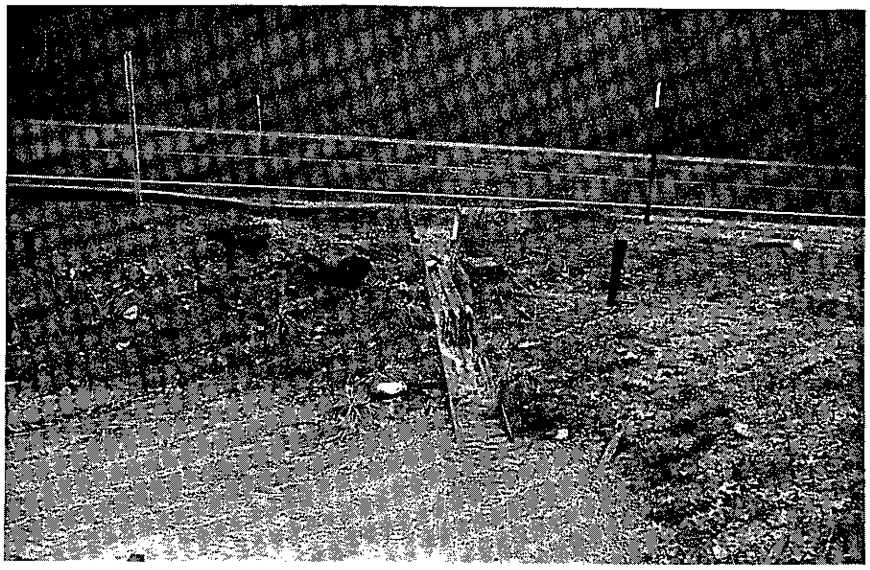
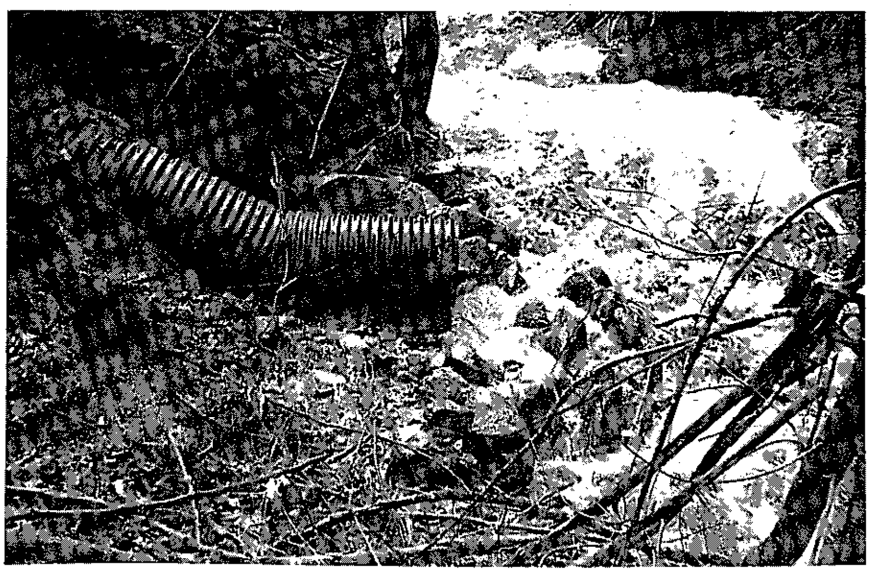


A-23-1
1/26/83
Near peak of
100 year storm

A-23-2
1/26/83
Scour path
highway inflow



A-23-3
1/27/83
Outlet
scoured

Figure A-23, Site 5 Post Mile 70.66

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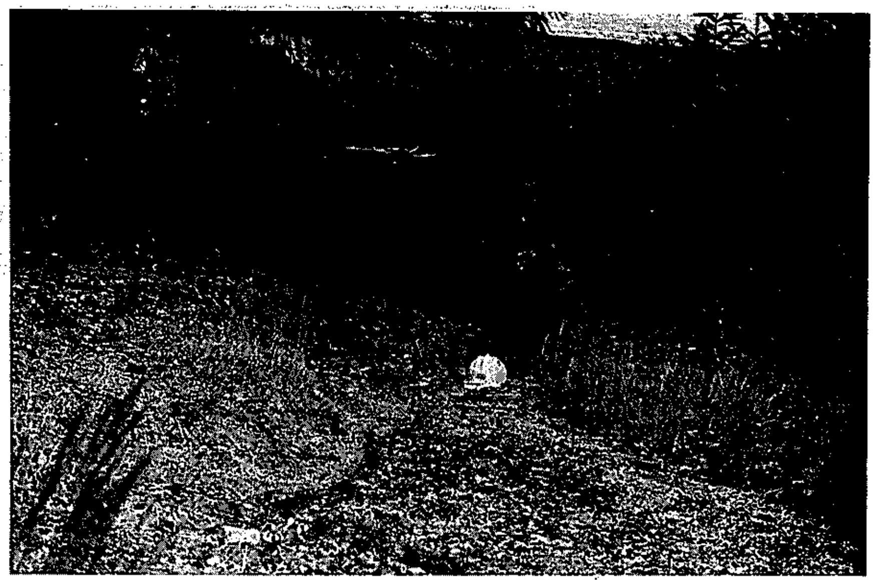
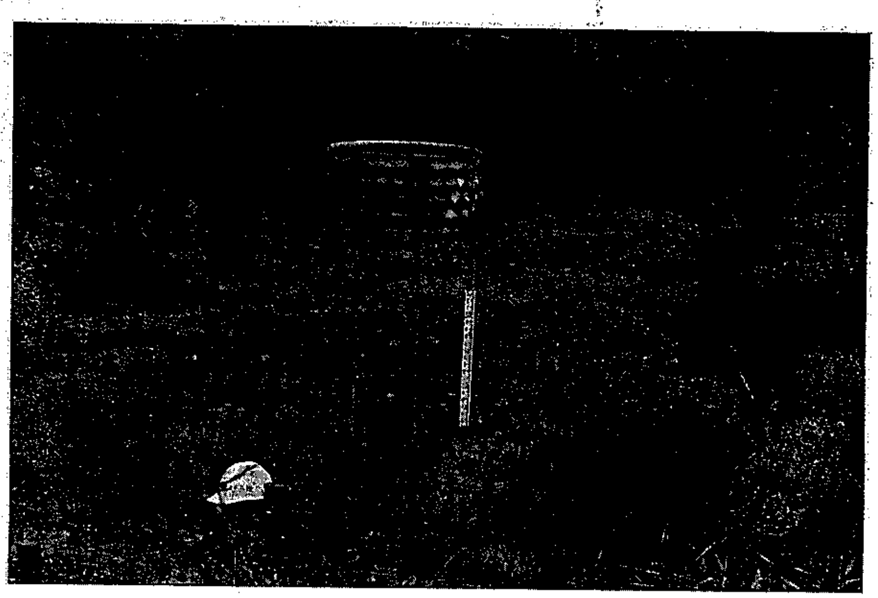


A-24-1
6/83
Channel scoured
from highway inflow



A-24-2
6/83
Basin is passing
majority of sediment

Figure A-24, Site 5 Post Mile 70.66

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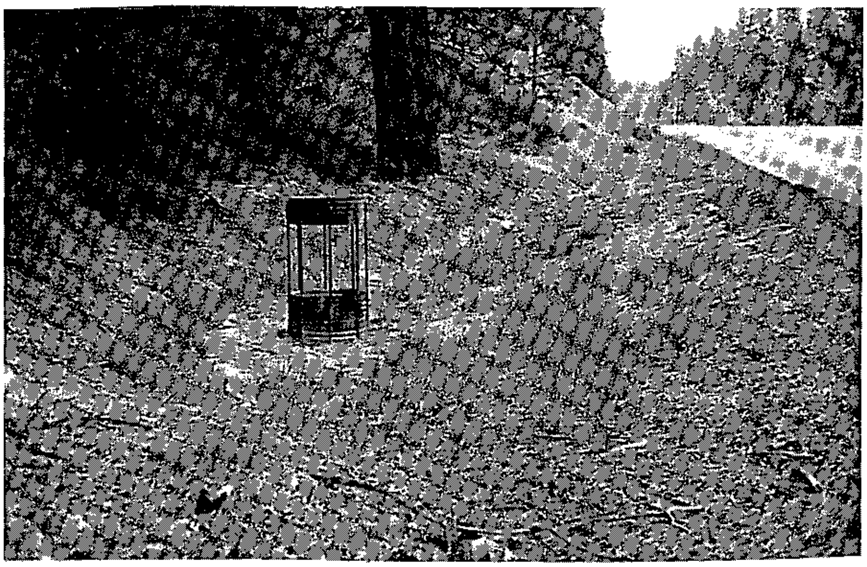
A-25-1
5/23/79

A-25-2
5/7/80



A-25-3
5/7/80

Figure A-25, Site 6 Post Mile 71.17

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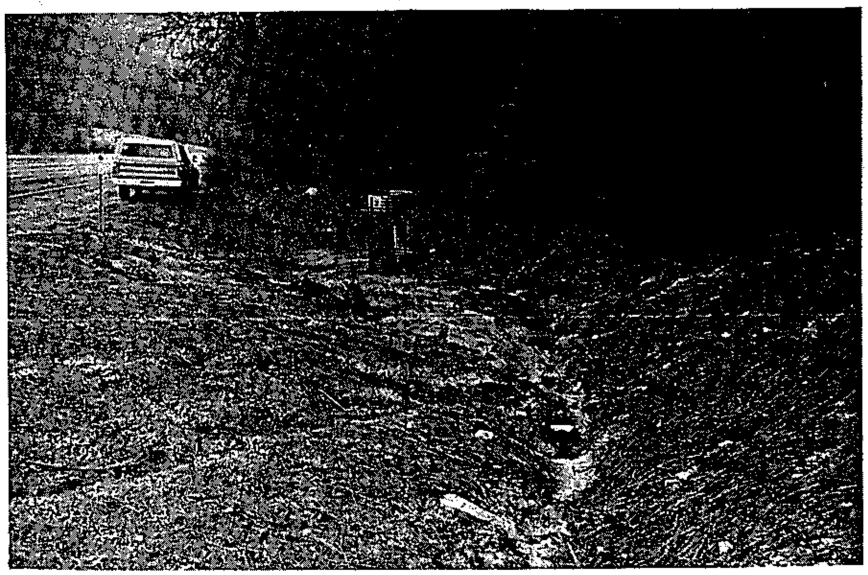
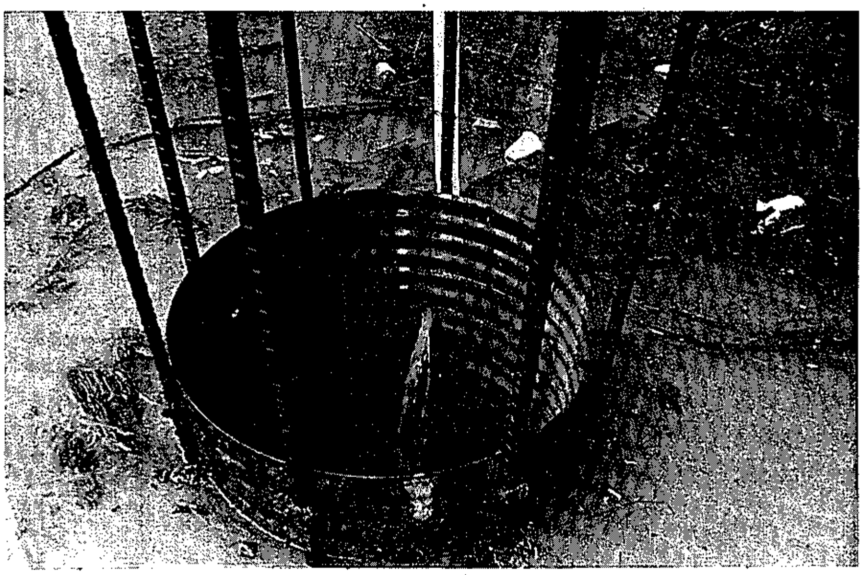
A-26-1
1/18/83
2 year storm

A-26-2
1/18/83





A-26-3
1/18/83
Runoff passing
through slots

Figure A-26, Site 6 Post Mile 71.17

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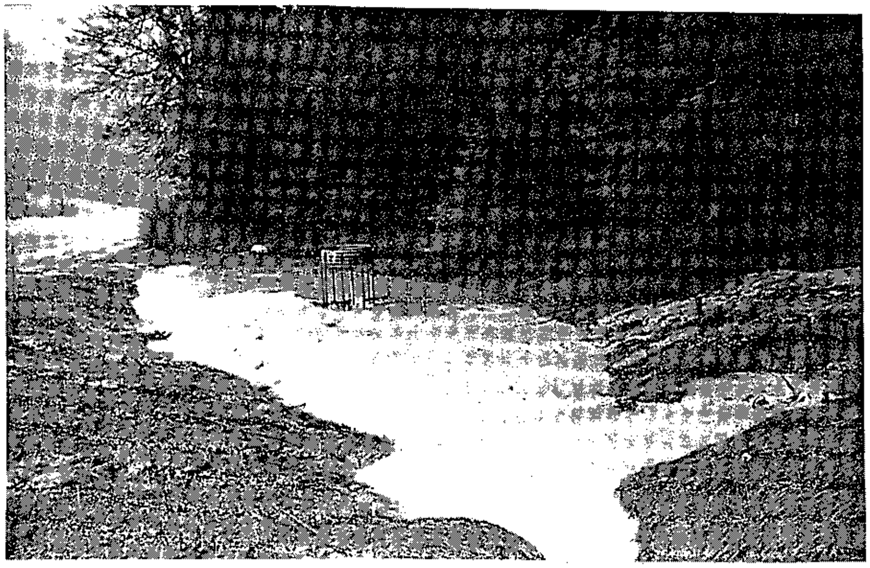

A-27-1
1/26/83
near peak of
100 year storm

A-27-2
1/27/83
Major upland
sediment
deposit

A-27-3
1/27/83
Scour on left
side of Douglas
fir

Figure A-27, Site 6 Post Mile 71.17

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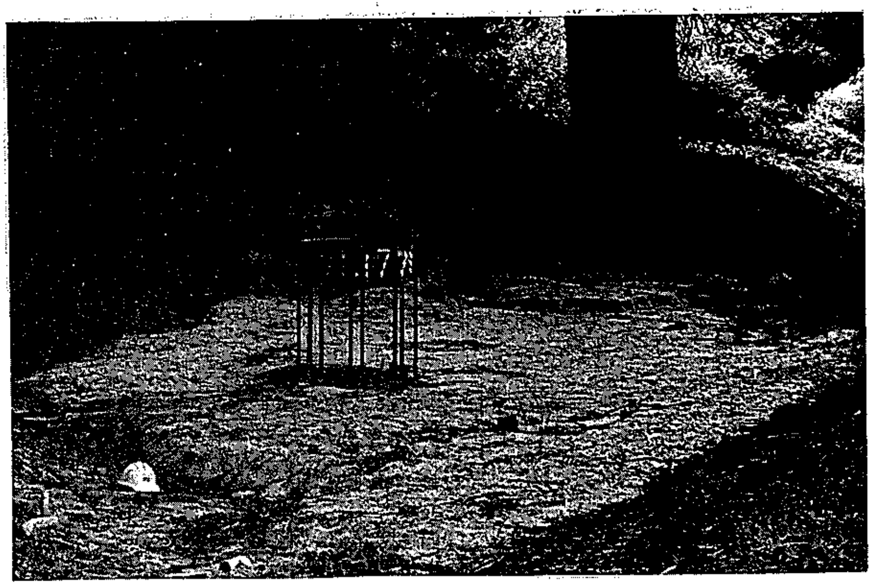
A-28-1
6/83
Scour from
upland flow

A-28-2
6/83
Sediment passed
over riser lip



A-28-3
6/83

Figure A-28, Site 6 Post Mile 71.17

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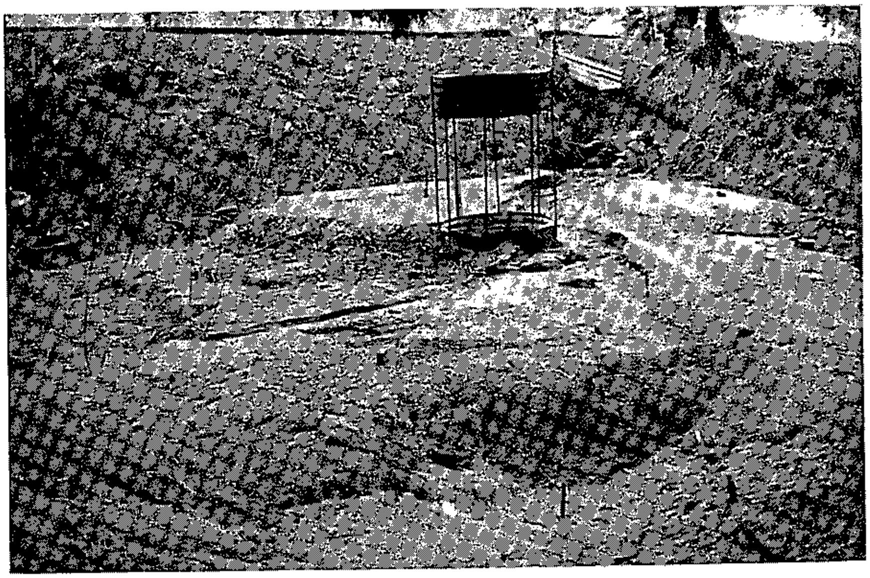
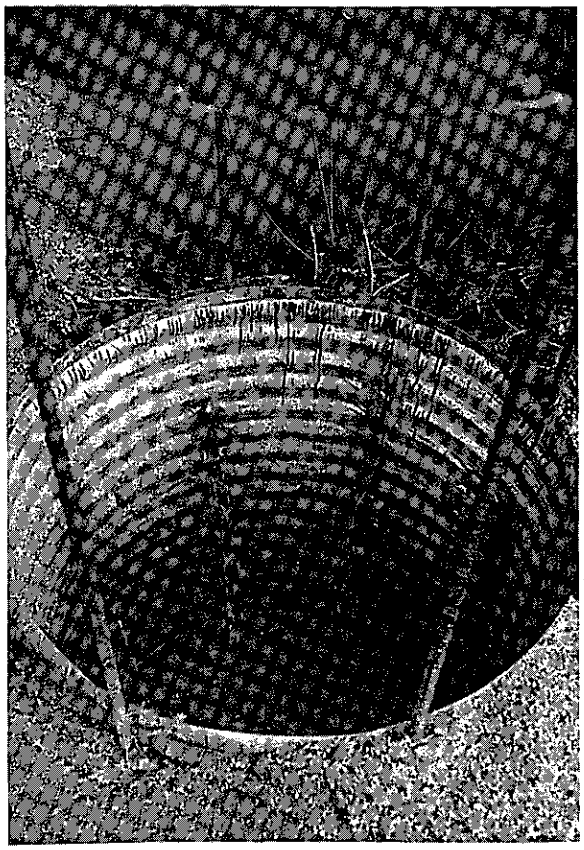


A-29-1
2/21/80
Before a
storm



A-29-2
2/21/80
After storm,
runoff passing
through slots

Figure A-29, Site 7 Post Mile 71.36

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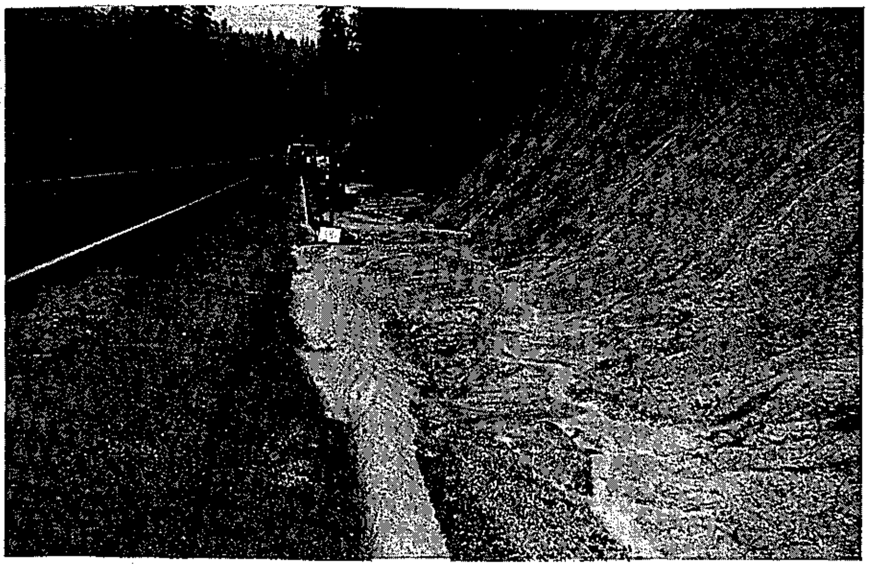

A-30-1
1/18/83
2 year storm, most of runoff bypassed dike and went down unpaved road

A-30-2
1/18/83

A-30-3
1/18/83
Runoff from flume downdrain going directly to riser

Figure A-30, Site 7 Post Mile 71.36

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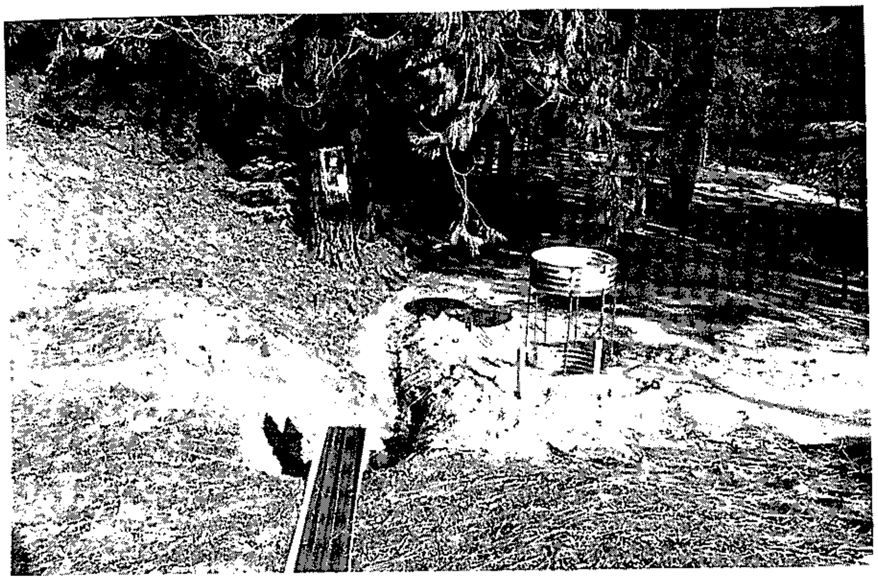
A-31-1
1/24/83
Upland source
of sediment



A-31-2
1/24/83
Scour from
highway runoff

Figure A-31, Site 7 Post Mile 71.36

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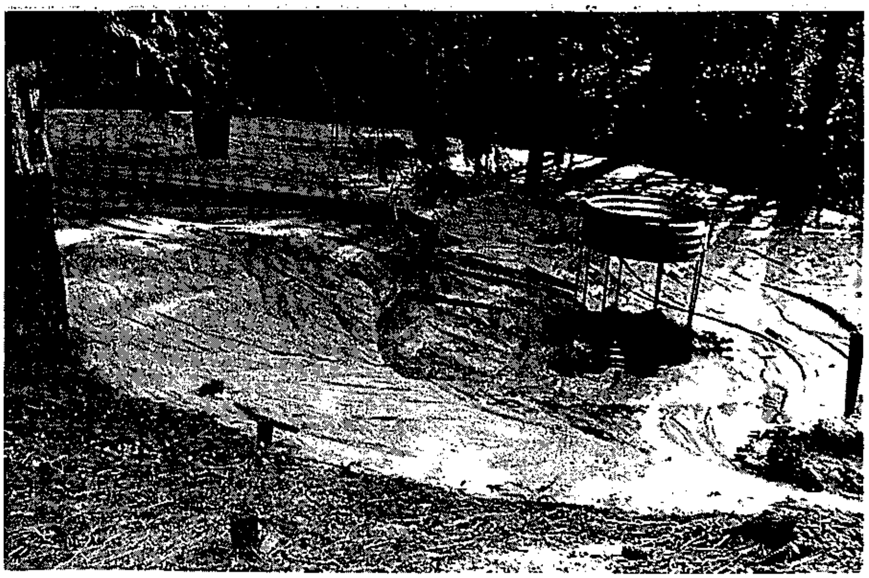
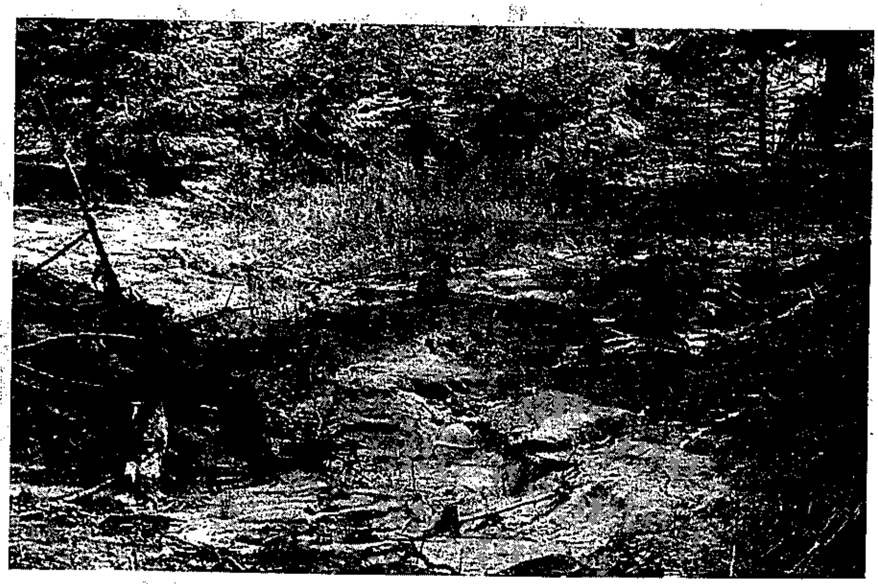
A-32-1
1/26/83
Near peak of
100 year storm



A-32-2
1/27/83
Sediment fans
and scour from
upland



A-32-3
1/27/83
Upland scour

Figure A-32, Site 7 Post Mile 71.36

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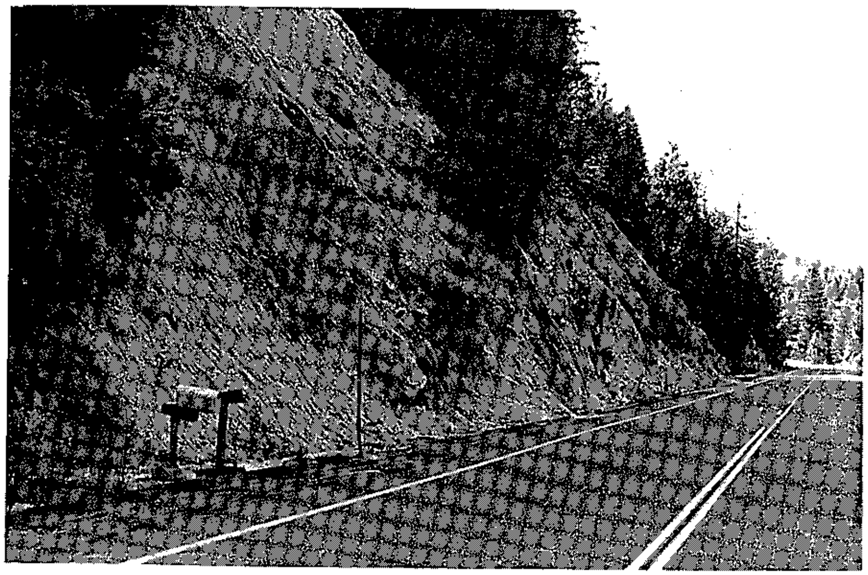
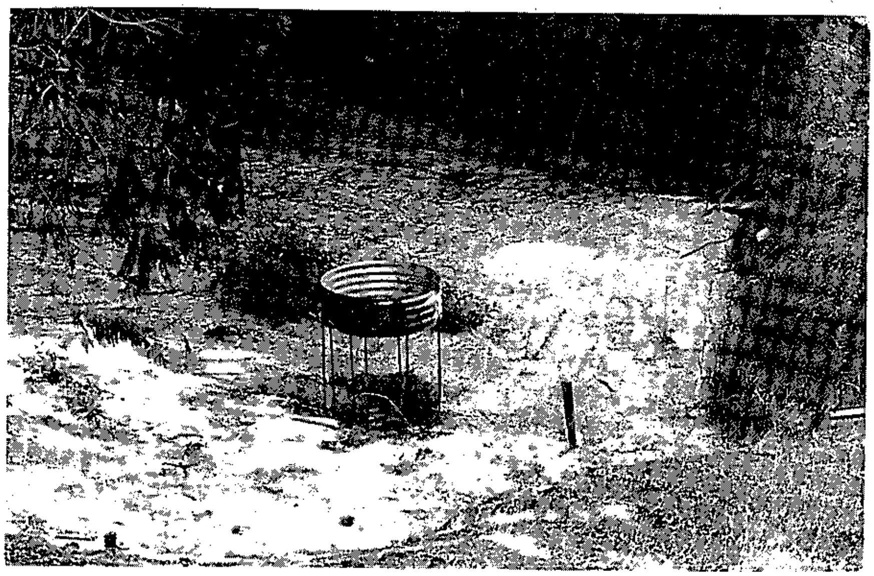


A-33-1
6/83
Highway cut
slope upstream
of basin

A-33-2
6/83
Unpaved road
adjacent basin



A-33-3
6/83
Basin full

Figure A-33, Site 7 Post Mile 71.36

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(a) is or will be 25 feet or more in height from the natural bed of the stream or watercourse at the downstream toe of the barrier, as determined by the department, or from the lowest elevation of the outside limit of the barrier, as determined by the department if it is not across a stream channel or watercourse, to the maximum possible water storage elevation or (b) has or will have an impounding capacity of 50 acre–feet or more.

"6003. Any such barrier which is or will be not in excess of 6 feet in height, regardless of storage capacity, or which has or will have a storage capacity not in excess of 15 acre–feet, regardless of height, shall not be considered a dam."

7–821.8 Debris and Detritus

There are two solutions to these problems:

(a) Retain solids upstream from the entrance, or
(b) Pass them through the culvert.

If economically feasible, every effort should be made to pass the debris and detritus through the culvert. Culvert design which passes debris often has a higher construction cost. On the other hand, retaining solids upstream from the entrance by means of a debris control structure often involves substantial maintenance cost. An economic comparison should be made to determine which method of handling should be used. If it is not economical to pass the debris, the solids should be retained upstream from the entrance by means of a debris control structure.

The FHWA Hydraulic Engineering Circular No. 9, "Debris–Control Structures", is a guide that shows types of debris control structures and provides a guide for selecting the type of structure suitable for various debris classifications.

If drift and detritus are retained upstream, a riser or chimney may be required. This is a vertical extension to the culvert which provides relief when the main entrance is plugged. The increased head should not be allowed to develop excessive velocities or cause pressure which might induce leakage in the culvert.

If debris control structures are used, access shall be provided for maintenance equipment to reach the site.

7–821.9 Entrance Design

The size and shape of the entrance are among the factors that control the level of ponding at entrance just as the capacity of a culvert is affected by the velocity head and the entrance losses. Devices such as rounded or beveled lips or an expanded entrance help maintain or utilize the velocity of approach, increase the culvert capacity, and may lower costs by permitting a smaller sized culvert to be used. The FHWA Hydraulic Engineering Circular No. 13 titled "Hydraulic Design of Improved Inlets for Culverts" is a good guide for selecting inlet geometry to improve culvert performance.

The design charts in the FHWA Hydraulic Engineering Circulars No. 5 and 10 account for entrance losses for various heads based on the entrance types stated therein. For entrances not covered by these charts, Hydraulic Engineering Circular No. 13 referred to above may be used. In transition structures designed to maintain the velocity of approach, the entrance loss is the head loss in the transition.

Except for transitions, the entrances discussed below are the types most frequently used and can be provided at reasonable costs.

(1) *Rounded Lip Entrance.* This treatment costs little, smoothes contraction, increases culvert capacity, and reduces the level of ponding at entrance. Consequently, the standard plans for box culverts show a rounded lip at the top and sides for straight headwalls on a skew or normal to the culvert axis, and a rounded lip only at the top for flared wingwalls. The rounded lip is also required for culverts 48 inches in diameter or larger. For diameters less than 48 inches the initial corrugation of annular corrugated metal pipe and the beveled groove end of concrete pipe, when placed at entrance, produces an effect similar to that of a rounded lip.

(2) *Expanded Entrances.* Headwalls with straight flared wingwalls or warped wingwalls offer a more highly developed entrance appropriate for large culverts, regardless of type or shape of barrel. The effect of such entrances can be approximated more economically by a shaped entrance using air blown mortar, concreted riprap, sacked concrete or slope paving.

Straight flared wingwalls and warped wingwalls aid in maintaining the approach velocity, align and guide drift, and funnel the flow into the culvert entrance. To insure enough velocity to carry the drift and detritus through the culvert or to increase the velocity and thereby increase the capacity, a sloping drop down apron at the entrance may be used. To minimize snagging drift, the standard plans require wingwalls to be flush with the culvert barrel. The flare angle may range from 30 to 75 degrees; the exact angle is based on the alignment of the approach channel banks and not the axis of the culvert. Greater efficiency is obtained when the wingwalls correspond in height with the top of the headwall at their junction with the headwall.

Whether warped or straight flared wingwalls are used depends on the shape of the approach channel. Straight flared wingwalls are appropriate for well defined channels with steep banks. Warped wingwalls are more suited to shallow trapezoidal approach channels.

Usually it is more economical to transition between the stream section and the culvert by means of straight flared wingwalls or warped wing-

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walls than to expand the culvert barrel at entrance. For a very wide channel, this transition may be combined with riprap, dikes, or channel lining extending upstream to complete the transition.

(3) *Transitions.* Elaborate transitions and throated openings for culverts may be warranted in special cases. Generally a highly developed entrance is unnecessary if the shape of the culvert fits the approach channel. In wide flat channels where ponding at entrance must be restricted, a wide shallow structure or multiple conduit should be used if drift and debris is not a problem.

Throated or tapered barrels at entrance are more vulnerable to clogging by debris. They are not economical unless they are used for corrective measures; for example, where there is a severe restriction in right of way width and it is necessary to increase the capacity of an existing culvert structure.

(4) *Entrance Risers.* At a location where the culvert would be subject to plugging, a vertical pipe riser should be provided as a supplement to the culvert entrance. For high fills, a relief riser usually should be provided as a safety measure. See FHWA Hydraulic Engineering Circular No. 9, "Debris–Control Structures".

7–821.10 Outlet Design

Improved culvert outlets are designed to restore natural flow conditions downstream. Outlets should be carefully scrutinized for conditions which produce scour. Where progressive erosion is to be expected, corrective measures such as bank protection, vertical flared wingwalls, warped wingwalls, transitions, and energy dissipators may be considered. See "Bank and Shore Protection in California Highway Practice", FHWA Hydraulic Engineering Circulars No. 11, "Use of Riprap for Bank Protection", and No. 14, "Hydraulic Design of Energy Dissipators for Culverts and Channels", and "Hydraulic Design of Stilling Basins" by the U. S. Department of Interior, Bureau of Reclamation, 1964. When dealing with erosive velocities at the outlet, the effect on downstream property should also be evaluated.

Wingwall flare angles should be carefully selected to prevent embankment scour from eddy action at the ends of the wingwalls. Both types of wingwalls should be flush with the culvert barrel and flared at an angle appropriate to the lines of the flow, particularly at high discharge velocities.

7–821.11 Headwalls and Other End Treatments

(1) *General Requirements.* The need for culvert headwalls or other structures, at either entrance or outlet, should be based on the physical, hydraulic, safety and aesthetic conditions peculiar to the site. As Index 7–821.9 covers rounding and other more sophisticated entrance treatments, the ensuing discussion covers the use of prefabricated flared end sections, headwalls, and wingwalls.

(2) *Flared End Sections and Headwalls.* Flared end sections or headwalls may be required at the entrance for these reasons:

(a) For hydraulic efficiency.
(b) To prevent a flow outside the culvert barrel in pervious backfill materials.
(c) To prevent erosion of steep embankment slopes due to a frequently recurring headwater pool.
(d) Acting as a counterweight, a headwall helps to prevent flotation at the entrance of culverts caused by plugging of the opening and the resulting ponding.
(e) Where the culvert is exposed to view.

Headwalls or flared end sections should be used on all culverts under the above conditions and are required for culverts with diameters greater than 60 inches and for pipe arches of equivalent size. For these large culverts, the half–height (Type C) pipe headwall or flared end sections constitute the minimum end treatment.

For hydraulic reasons, flared end sections and headwalls are not required at entrance under the following conditions:

- For intermittent, low velocity flows where head conservation is not important.
- Where the design discharge is insufficient to fill the opening of a minimum size pipe.

Although it may be unnecessary to place end treatment at culvert outlets for hydraulic reasons, aesthetic or safety considerations may dictate their use. Headwalls, flared end sections, or other protection such as rock slope protection is essential, regardless of culvert size, where a degrading channel may undermine the culvert or erode the embankment. Sectional pipes are particularly vulnerable to disjointing under these conditions. Whenever erosive or excessive velocity conditions are encountered at an outlet, it may be necessary to use an energy dissipator in lieu of headwalls, wingwalls or flared end sections. Before an end treatment is considered, the effects of the discharge on both the outlet structure and the downstream property must be evaluated.

Acceptable end treatments are described as follows:

- Flared End Sections—As they provide better appearance, a safer roadside and an effective entrance, prefabricated flared end sections shall be used in lieu of headwalls whenever feasible. Flared end sections should be provided at both entrance and outlet where embankment slopes are flatter than 2:1. The pipe must be extended when used in conjunction with flatter slopes. Flared end sections lend themselves well to situations calling for fill widening.
- Straight Headwalls—For safety and aesthetic

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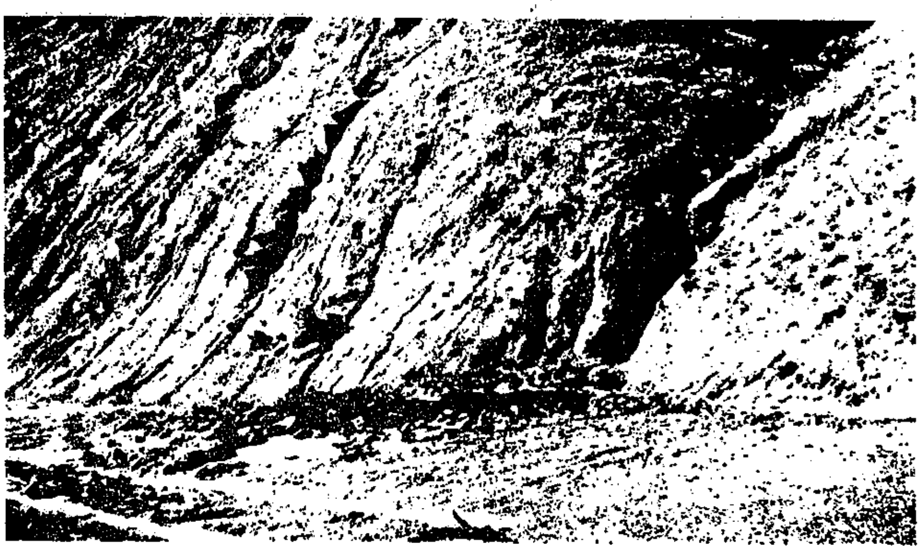

FIGURE 17. Typical small culvert failure caused by deposition of detritus and light floating debris at culvert entrance due to abrupt grade break at roadway gutter.

out completely shutting off the entry of water into the culvert. (Fig. 18.)

Where the open crib type is used as a riser in anticipation of a considerable depth of detritus, as in a debris basin, it should be built well above the estimated height of deposit on the culvert entrance, with provision for further increase in height as required. (Fig. 19.)

Debris Riser

In mountainous terrain involving high embankments, a common drainage practice requires the location of a culvert in the bottom of a waterway which places the culvert entrance in the lowest part of a debris basin susceptible to rapid filling with flowing detritus.

At such locations it is essential that the muck be kept from entering and clogging the culvert entrance. A successful solution to this problem requires a vertical riser of perforated construction either of pipe, timber, or concrete, placed directly over the culvert entrance. Perforations or openings in the riser should be large enough to permit entry of water and small enough to exclude entry of muck. The barrel or chimney should be carried well above any anticipated deposit and increased in height as necessary. (Fig. 24.)

Debris Basin

In certain mountainous areas of easily eroded materials, particularly granitic materials, with steep slopes and heavy run-off, it has been found to be economically impractical to provide a culvert large enough to safely carry surges of flowing detritus.

The perforated debris riser as an expedient solution prevents clogging of the culvert entrance at a critical period when the debris basin is filling with a surging heterogeneous mass of muck, rock, and debris from surface accumulations. The basin simply acts as a reservoir to store the

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flowing detritus until it can be de-watered by the perforated debris riser and later removed under periodic maintenance operations.

Under certain conditions, the debris riser may be progressively built up and an extensive debris table formed, which will be self-sustaining to a greater extent year by year, finally depositing its load at a safe distance above the culvert entrance.

Debris Spillway

The most serious losses of embankment were found to have occurred in mountainous areas throughout the State where debris basins proved inadequate, resulting in water overflowing the roadway embankment causing complete washouts.

The investment in heavy embankments across the ravines encountered in rough terrain definitely warrants not only ample principal drainage, but the development of auxiliary drainage facilities as a factor of safety.

The debris spillway, as an adjunct to the debris basin, is considered by the committee to be one of the foremost improvements in California drainage practice developed subsequent to the 1938-40 storms—notably on the Angeles Crest Highway east of La Canada in Los Angeles County. (*17*) (Figs. 25-27.)

As pointed out in the previous chapter on comparative hydrology, the storm of 100-yr frequency occurs every year at scattered places in California; and when it does occur, the damage is usually serious. The expense of providing against heavy damage from even the 100-yr frequency storm is relatively small.

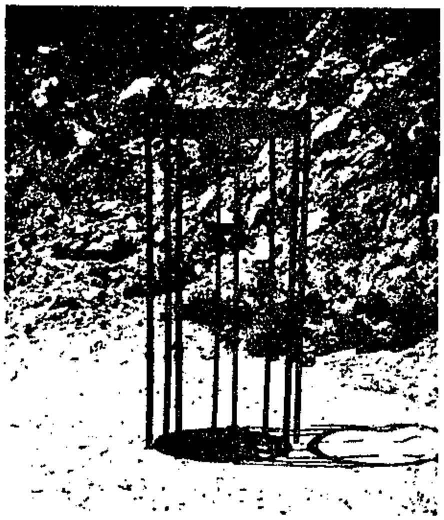

FIGURE 24. Metal debris riser placed over culvert entrance in debris basin. Note provisions for extension when debris basin has filled to such an extent as to cause deposition of most of the detritus before it reaches the riser.

The combination debris basin—spillway plan of drainage—consists of a debris basin provided with a culvert and riser for normal drainage, supplemented by auxiliary drainage facilities wherein flowage into the roadbed from an overtaxed debris basin is confined inside the shoulder dykes and flows down the channelized roadbed until a safe and natural place is found to spill the water from the roadway.

Debris basin spillways should be lined so as to be capable of resisting erosion. In many cases on grades, these spillways may be several hundred feet from the debris basin originating the flow.

Dykes and spillways, to be successful, must necessarily be constructed on an adequately large scale plan.

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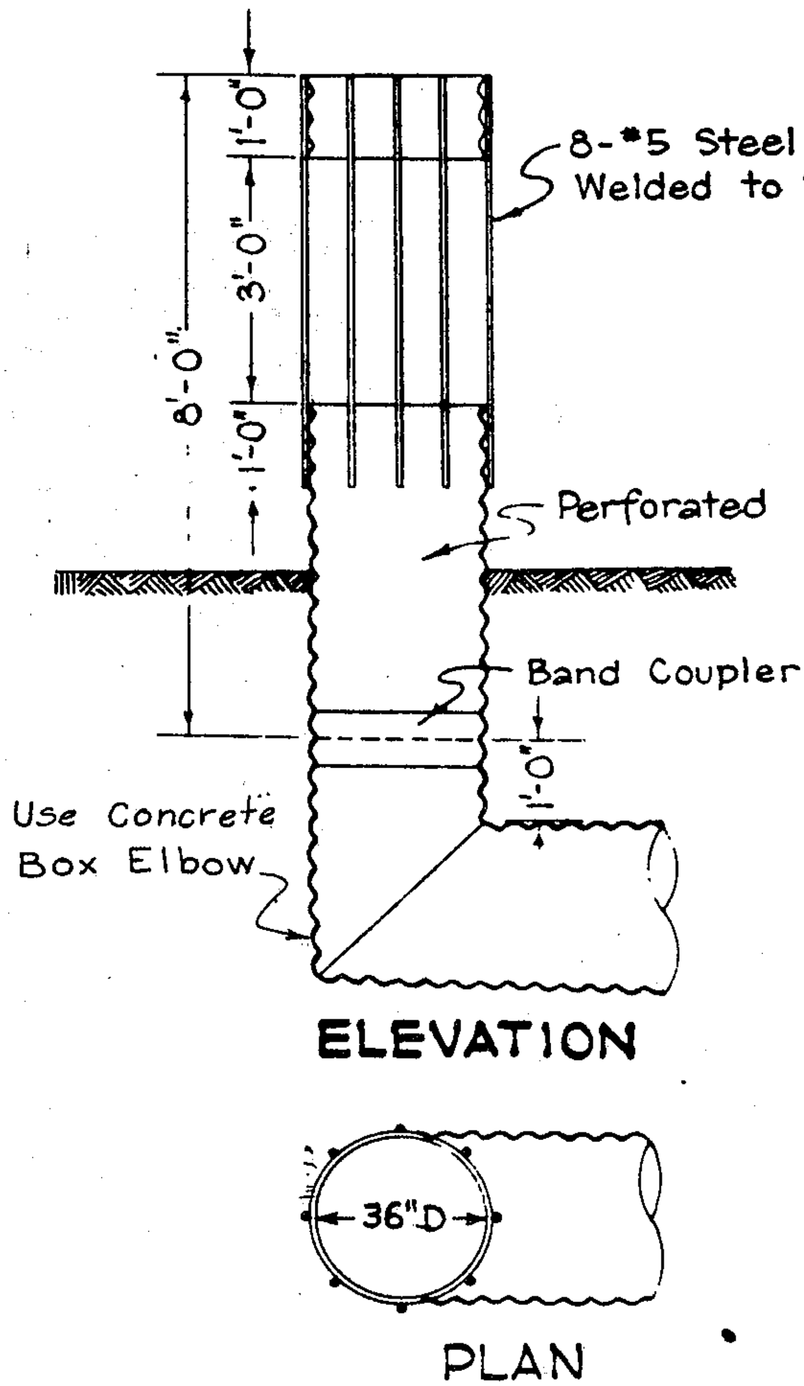
PLATE VII



DEBRIS RISER

California Division of Highways
District II

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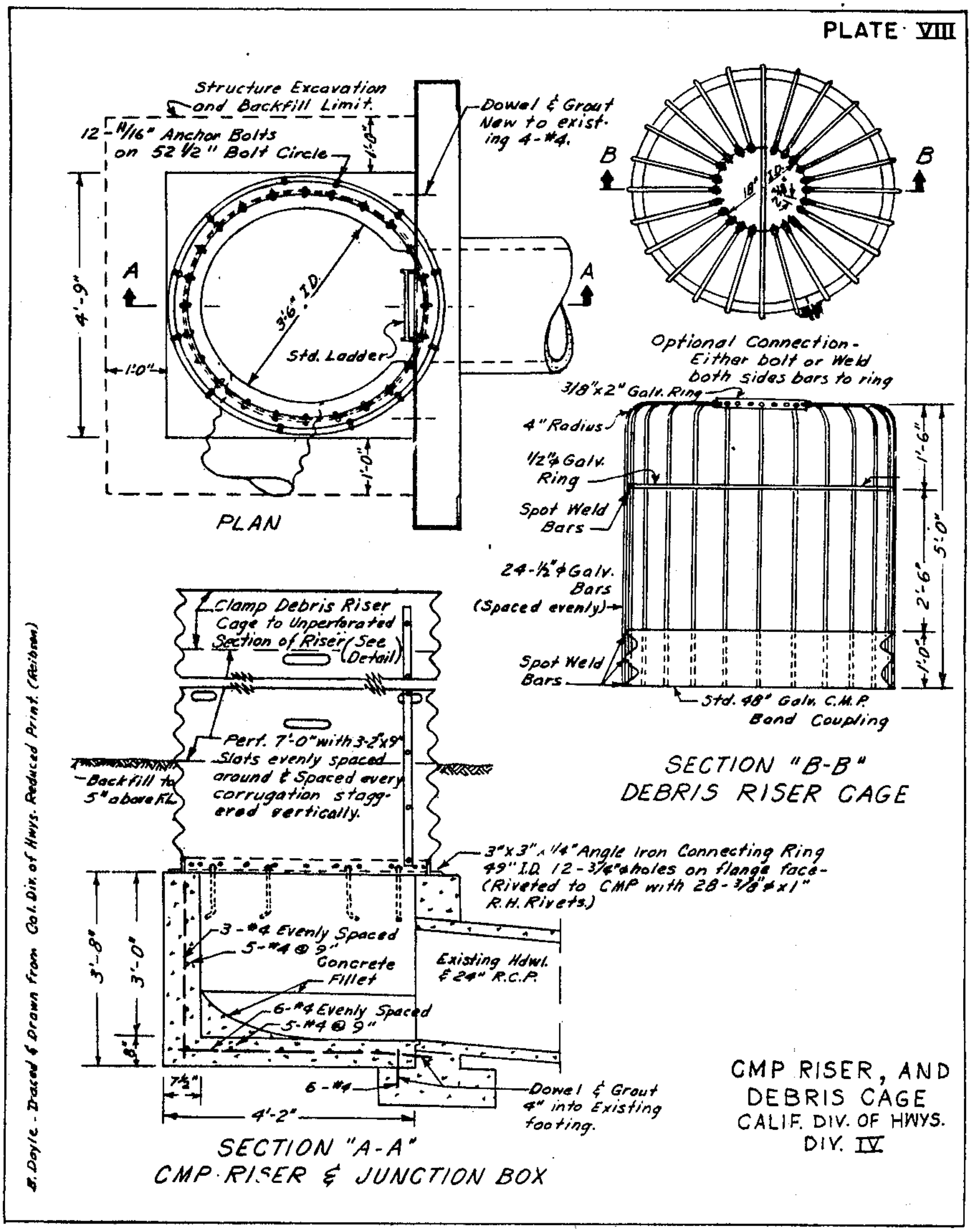

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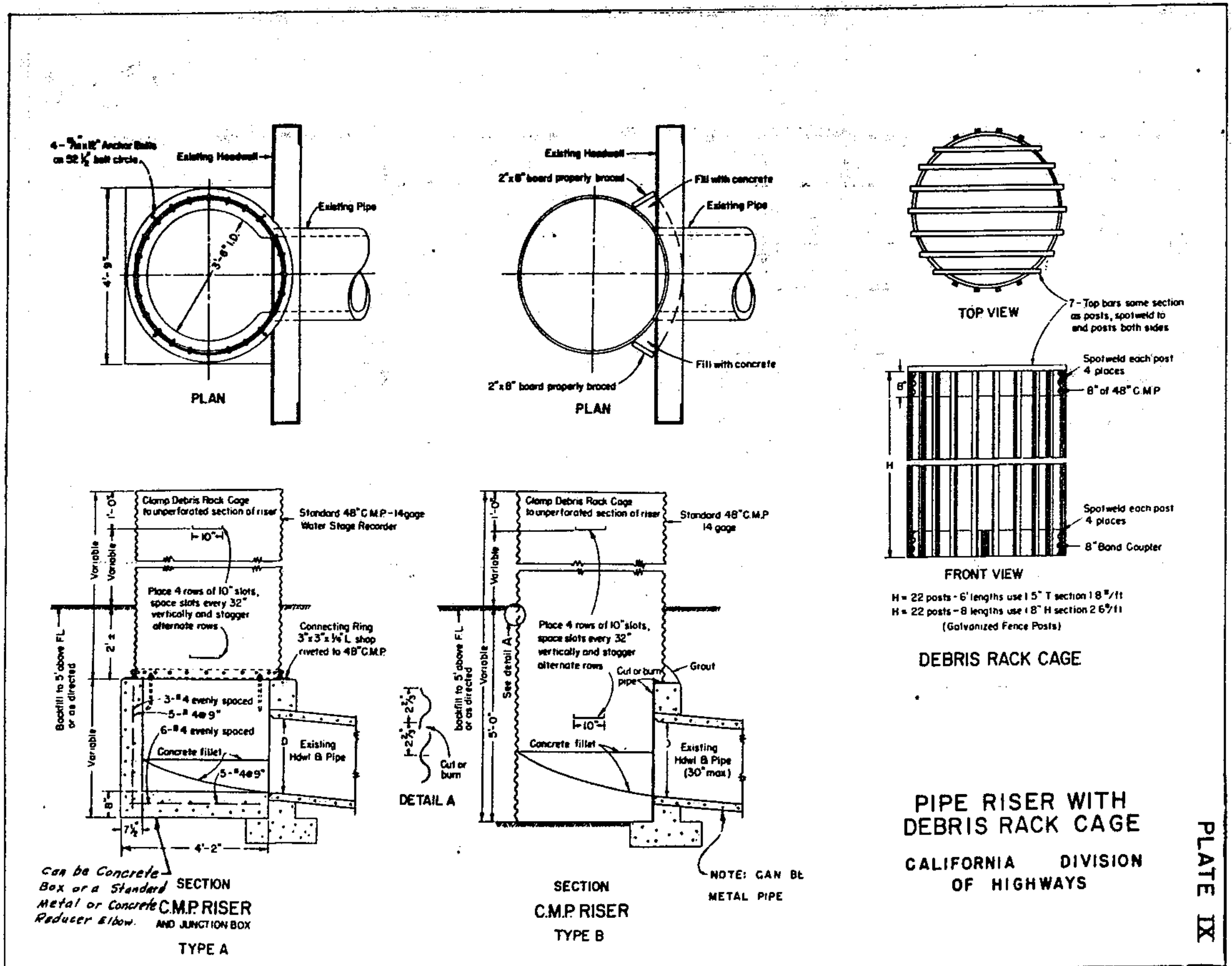
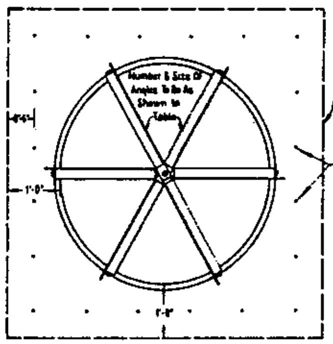


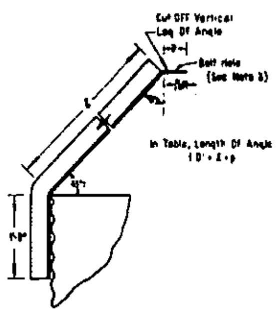
PLATE IX
4-⅝"x18" Anchor Bolts on 52½" bolt circle
Existing Headwall
Existing Pipe
3'-6" I.D.
4'-9"
PLAN
2"x8" board properly braced
Fill with concrete
Existing Pipe
Fill with concrete
2"x8" board properly braced
PLAN
TOP VIEW
7-Top bars same section as posts, spotweld to end posts both sides
Spotweld each post 4 places
8" of 48" C.M.P
Spotweld each post 4 places
8" Band Coupler
FRONT VIEW
H = 22 posts - 6' lengths use 1.5" T section 1.8#/ft
H = 22 posts - 8 lengths use 1.8" H section 2.6#/ft
(Galvanized Fence Posts)
DEBRIS RACK CAGE
Clamp Debris Rack Cage to unperforated section of riser
Standard 48" C.M.P-14gage Water Stage Recorder
Place 4 rows of 10" slots, space slots every 32" vertically and stagger alternate rows
Connecting Ring 3"x3"x¼" L shop riveted to 48" C.M.P
Backfill to 5' above FL or as directed
3-#4 evenly spaced
5-#4@9"
6-#4 evenly spaced
Concrete fillet
5-#4@9"
Existing Hdwl & Pipe
4'-2"
Can be Concrete Box or a Standard Metal or Concrete Reducer Elbow.
SECTION
C.M.P RISER
AND JUNCTION BOX
TYPE A
Cut or burn
DETAIL A
Clamp Debris Rack Cage to unperforated section of riser
Standard 48" C.M.P 14 gage
Place 4 rows of 10" slots, space slots every 32" vertically and stagger alternate rows
Cut or burn pipe
Grout
Concrete fillet
Existing Hdwl & Pipe (30" max)
See detail A
backfill to 5' above FL or as directed
NOTE: CAN BE METAL PIPE
SECTION
C.M.P RISER
TYPE B
PIPE RISER WITH DEBRIS RACK CAGE
CALIFORNIA DIVISION OF HIGHWAYS

NOTES:

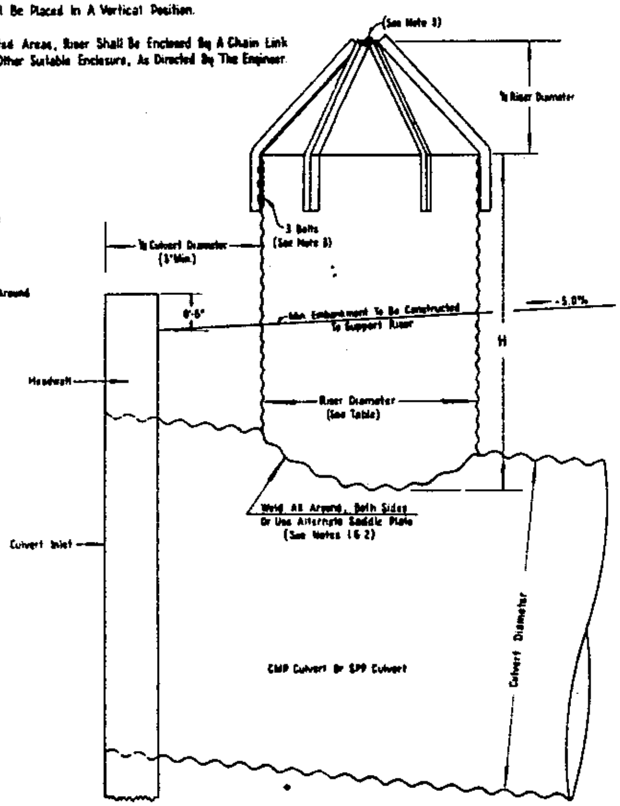
1. Riser To Be Fastened To Culvert By Welding Or Shop-Made Corrugated Metal Saddle Plate.
2. Saddle Plate Shall Be Same Gage Metal As Top Culvert Plates.
3. Cage Angles Shall Be Either Welded Or Bolted To Riser, And Top Joint Of Cage Angles Shall Be Either Welded Or Bolted. Bolt Diameter Shall Be Twice Angle Thickness.
4. All Angles, Nuts And Bolts Shall Be Galvanized.
5. All Welds On Galvanized Metal Shall Be Treated With Zinc Dust In Accordance With Section 66-1.02 G Of The Standard Specifications.
6. Riser Shall Be Placed In A Vertical Position.
7. In Populated Areas, Riser Shall Be Enclosed By A Chain Link Fence Or Other Suitable Enclosure, As Directed By The Engineer.



TOP VIEW
No Scale



CAGE ANGLE DETAIL
No Scale



ELEVATION
No Scale

0 1 2 3
SCALE IN FEET

CULVERT DIAM.	RISER			RISER CAGE				
	C.M.P		H*	STEEL				
	DIAM.	GAGE		ANGLE SIZE	NO. OF PIECES	LENGTH, FT.		
INCHES	INCHES		FEET			E	P	L
36	24	14	4	2" x 2" x ¼"	4	1'-5"	2"	2'-7"
42	24	14	4	2" x 2" x ¼"		1'-5"	2"	2'-7"
48	30	14	4	2½" x 2½" x ¼"		1'-10"	3"	3'-1"
54	36	12	4			2'-1"	3"	3'-4"
60	42	12	6			2'-6"	3"	3'-9"
66	42	12	6			2'-6"	3"	3'-9"
72	48	12	6			2'-10"	3"	4'-1"
78	48	12	6			2'-10"	3"	4'-1"
84	54	12	6	3" x 3" x ¼"		3'-3"	3"	4'-6"
90	60	10	8			3'-6"	3"	4'-9"
96	60	10	8			3'-6"	3"	4'-9"
102	66	10	8			3'-11"	3"	5'-2"
108	72	10	8	3½" x 3½" x 5/16"		4'-3"	4"	5'-7"
114	72	10	8			4'-3"	4"	5'-7"
120	78	8	8			4'-8"	4"	6'-0"
126	84	8	10			5'-0"	4"	6'-4"
132	84	8	10			5'-0"	4"	6'-4"
138	90	8	10		6	5'-4"	7"	6'-11"
144	96	8	10			5'-8"	7"	7'-3"
150	96	8	10			5'-8"	7"	7'-3"
156	102†	12	12	4" x 4" x 3/8"	8	6'-0"	11"	7'-11"
162	108†	12	12			6'-5"	11"	8'-4"
168	108†	12	12			6'-5"	11"	8'-4"
174	114†	10	12			6'-9"	11"	8'-8"
180	120†	10	12			7'-1"	11"	9'-0"

* H May Be Varied. See Culvert Detail Sheets For Variable H.
† Structural Plate Pipe.

STANDARD RELIEF RISER
CALIFORNIA DIVISION OF HIGHWAYS

PLATE X

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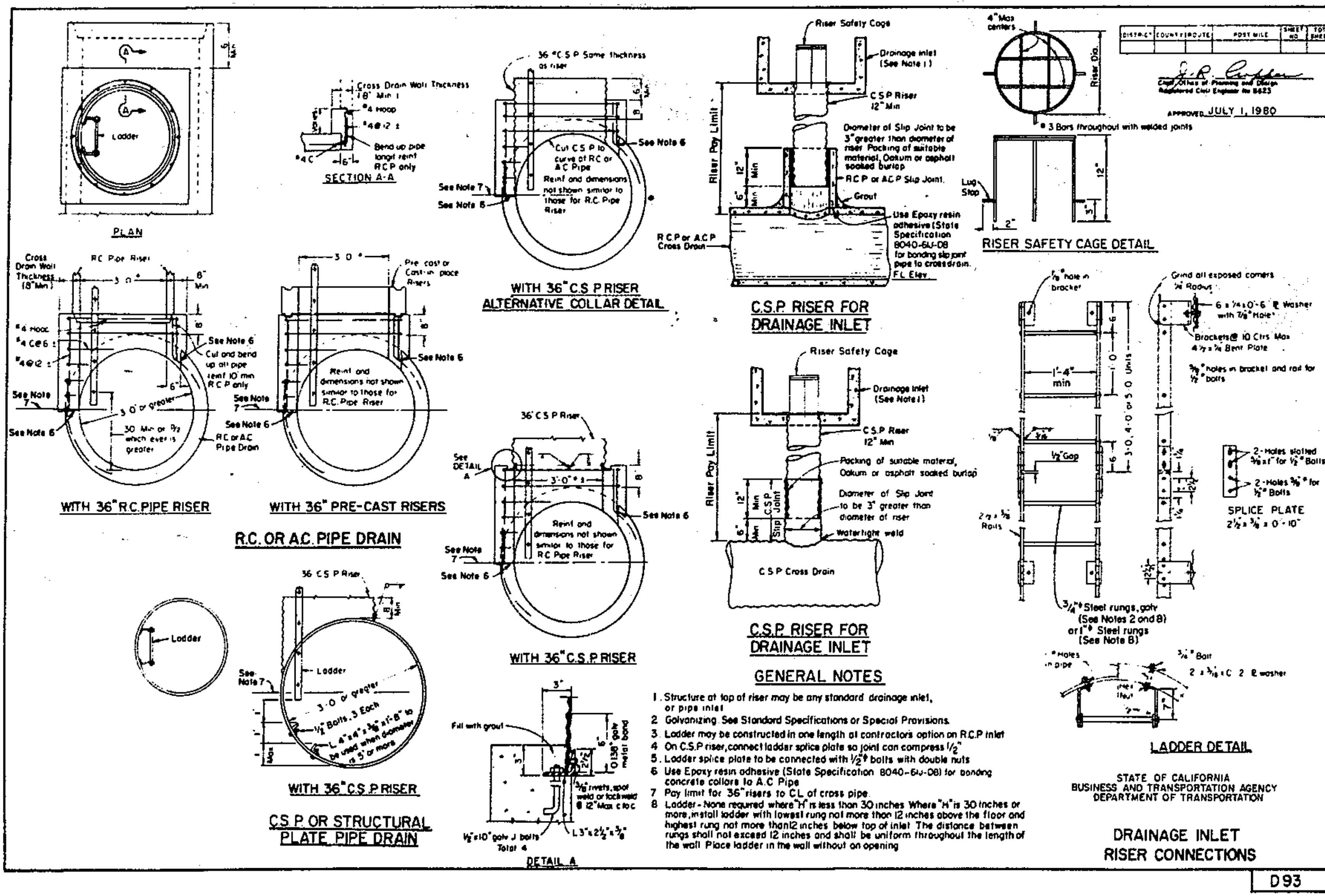

GENERAL NOTES

1. Structure at top of riser may be any standard drainage inlet, or pipe inlet
2. Galvanizing. See Standard Specifications or Special Provisions.
3. Ladder may be constructed in one length at contractors option on R.C.P inlet
4. On C.S.P riser, connect ladder splice plate so joint can compress 1/2"
5. Ladder splice plate to be connected with 1/2"ϕ bolts with double nuts
6. Use Epoxy resin adhesive (State Specification 8040-61J-08) for bonding concrete collars to A.C Pipe
7. Pay limit for 36" risers to CL of cross pipe.
8. Ladder - None required where "H" is less than 30 inches Where "H" is 30 inches or more, install ladder with lowest rung not more than 12 inches above the floor and highest rung not more than 12 inches below top of inlet The distance between rungs shall not exceed 12 inches and shall be uniform throughout the length of the wall Place ladder in the wall without an opening

STATE OF CALIFORNIA
BUSINESS AND TRANSPORTATION AGENCY
DEPARTMENT OF TRANSPORTATION

DRAINAGE INLET
RISER CONNECTIONS

D93

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